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The Ascidians of the Japan Sea. I¹⁾

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With Text-figures 1-9 and Tables 1-4

Abstract The ascidian fauna in the Japan Sea was studied by examination of new material mainly from littoral areas and the type or other available specimens and by a literature survey of previous records. A total of 163 species, including infraspecific taxa, belonging to 50 genera of 14 families were recorded from this sea. Included are descriptions of five new species, proposal of a new replacement name and many taxonomic amendments. The fauna thus understood has been analyzed zoogeographically mainly in terms of biogeographic elements. Consideration of the results supports in many respects the previous knowledge about the biotic peculiarities of the sea, but also gives some new findings.

The Japan Sea is a marginal sea of the Pacific Ocean. It is separated nearly wholly from the ocean and maintains the in- and outflows of water mainly through the Straits of Korea (=Chosen), Tsugaru and Soya, scarcely through those of Mamiya (=Tatarskiy) and Tsushima. In this paper the Japan Sea area is to include these five straits and Mutsu Bay and Cheju (=Quelpart, Saishu) Island. The Japan Sea has been arousing interests in biogeography and offering the subject of debate about the origin and formation of the marine fauna. Many peculiarities have been noticed in the composition and distribution of marine animals there, which have been extensively enumerated by Nishimura (1965a, b, 1966a, 1967). In his detailed biogeographical analysis, however, the ascidians were left little dealt with. Indeed, the ascidian fauna of the Japan Sea is still poorly known.

The first work on the Japan Sea ascidians was presented by Traustedt (1885), and he described 4 species from the Korean coast and Hokkaido. Subsequently Hartmeyer (1906) reported 9 species from Hokkaido and Honshu. The ascidian fauna of the Japanese coast of the sea was then surveyed by Oka (1906, 1914, 1918, 1927d, 1929b, 1932f, 1935) and Tokioka (1949a, 1951a, 1953b, 1959a, b, 1962a, 1967b, c), providing 27 species from chiefly northern shores and 58 from the southern, respectively. Rho (1971, 1975) recorded about 50 species from the South Korean coast. The materials of Redikorzev (1911a, b, 1916, 1941) were restricted in geographical extent to the northern part of the Japan Sea, and included 30 species

1) This is the first of serial papers that are published in this journal as parts of the author's thesis.

mainly from the Peter the Great Bay and its vicinity. Recently Beniaminson (1971, 1975, 1976) and Romanov (1976) recorded 12 and 9 species respectively from the bay. I myself have made several contributions to the study of the Japan Sea ascidian fauna, and have reported 50 species from the coast of Honshu of Japan (Nishikawa, 1980a, 1981, 1982a, 1984b, 1986b). In addition, Ostroumov & Pavlenko (1911), Skalkin (1959) and Millar (1975) made brief reference to the fauna. However, the adequate information is still unavailable from the North Korean coast and the vast central part of the sea, and the overall consideration of the Japan Sea ascidian fauna has not yet been presented.

The endemism, if present, would be a key point to analyze the faunistic characteristics of the Japan Sea and to substantiate the hypothesis on its geological history as well. As for the ascidians there, Oka (1906) reported *Chelyosoma siboja* from the coasts of Hokkaido and northern Honshu, occurring commonly and abundantly, and affirmed that it was not found outside the Japan Sea, implying it to be endemic to the sea. Oka (1918) recorded *Megalodicopia hians* of monotypic genus from north off Sado Island, but this was later discovered by Tokioka (1953c) among the specimens from Sagami Bay on the Pacific coast of Honshu. Oka (1932f) again reported a new species of monotypic genus, *Azygocarpa mutuensis*, from Mutsu Bay, which had not been found in any other area. However, recent reexamination of the type material reveals that it is really *Cnemidocarpa clara* (Hartmeyer), a probable amphi-Pacific species, the results of which is involved in the present paper. *Adagnesia vesiculiphora*, once described by Nishikawa (1982a) from Toyama Bay, is also discovered among the specimens from the Pacific coast of Japan. Thus, it is proved that *C. siboja* is a species endemic to the Japan Sea, but there is no truly endemic ascidian genus. As is generally the case, it is naturally necessary to arrive at a reliable conclusion to make thorough examination and comparison of the specimens both from the sea and from other areas.

I have been studying the ascidians around Japan, based on the specimens collected by myself and newly afforded to me, as well as on the specimens already described and stored at research institutions. The present work provides a monographic account of the ascidians occurring in the Japan Sea and adjacent waters, which is the first presentation of the overall stage of the Japan Sea ascidian fauna. This work is necessarily accompanied with taxonomic revisions of many species. Faunistic outcome is the addition of 28 species belonging to 19 genera to the knowledge of the Japan Sea ascidian fauna. The taxonomical contribution is the proposal of 5 new species and one new replacement name, which are first described in this paper, and 42 amendments. Thus, the ascidian fauna of the Japan Sea is proved to consist of 14 families, 50 genera and 163 species (including several infraspecific taxa). Based on this result, considerations are made on the faunistic characteristics and biogeographical nature of the fauna in terms of the present structure of the water mass in the sea as well as its geological history.

The specimens collected by myself were first relaxed with pieces of menthol sprinkled on the water surface, then fixed with about 10% formalin and preserved therein; didemnids with calcareous

spicules are kept in about 70% ethanol. Prior to fixation, the coloration of specimens was usually noted. In the present paper, the animal removed from its test is termed "mantle body", which was coined by Tokioka (1951b). The term "lacunae" denotes here the common cloacal cavity of colony, to distinguish this colonial cavity from the dorsal part of peribranchial cavity in mantle body, that is sometimes called cloacal cavity.

Material examined: The following abbreviations are used to denote where specimens are deposited. AMNH, American Museum of Natural History; BLIH, Biological Laboratory, Imperial Household, Tokyo; BMNH, British Museum (Natural History); MNB, Museum für Naturkunde der Humboldt-Universität zu Berlin; NMNH, National Museum of Natural History, Smithsonian Institution; NSMT, National Science Museum (Natural History), Tokyo; OCUT, Oka Collection of the University of Tsukuba; SMBL, Seto Marine Biological Laboratory, Kyoto University; UZMK, Universitetes Zoologiske Museum, København; ZMA, Zoologisch Museum, Universiteit van Amsterdam; ZMH, Zoologisches Museum, Universität Hamburg.

In addition to the specimens of these museums or institutes, also examined are the specimens of the following collections:

A. Collection made by the R/V "Tansei-maru" of the Ocean Research Institute of the University of Tokyo, at the following 10 stations in Toyama Bay, 22–1410 m deep, June 2–4, 1975, and offered by C. Oguro of Toyama University to T. Tokioka for identification and then forwarded to me. The station data are: St. 8, 37°28.9'N and 137°23.4'E, 22–30 m; St. 11, 37°21.7'N and 137°18.3'E, 31 m; St. 12, 37°20.9'N and 137°18.3'E, 44 m; St. 15, 37°22.1'N and 137°16.8'E, 36 m; St. 21, 37°26.9'N and 137°44.2'E, 1380–1410 m; St. 24, 37°11.8'N and 137°06.9'E, 74–81 m; St. 25, 37°06.3'N and 137°06.6'E, 82 m; St. 28, 36°58.4'N and 137°04.4'E, 45 m; St. 29, 36°58.2'N and 137°05.3'E, 100 m; St. 30, 36°58.6'N and 137°06.6'E, 105–115 m.

B. Specimens of OCUT; the collection made by A. Oka, mainly from Mutsu Bay, as well as the Japan Sea coasts of Hokkaido and Honshu, Japan, or rarely from the Korean coasts.

C. Collections made in Japanese waters by my own shore samplings, as well as snorkel or SCUBA diving. C-1: Rocky shores of the Japan Sea coast of Hokkaido, northerly from the Rishiri and Rebun Is. southerly to Okushirijima Is. and Esashi, down to 8 m deep, July 26 to Aug. 10, 1983. C-2: Rocky shores of Mutsu Bay, down to 20 m, Aug. 21–22, 1980. C-3: Rocky shore of Fukaura, Aomori Prefecture, 3–7 m, Aug. 22, 1980. C-4: Tsukumo Bay, east coast of Noto Peninsula, 0–6 m, Aug. 20–21, 1975. C-5: Inlet Note-Hime, southwest of Tsukumo Bay, 0–2.5 m, Aug. 21, 1975. C-6: Anamizu Bay, Noto Peninsula, 0–1 m, Mar. 16–17, 1976. C-7: From the mole of the Fisheries Research Station, Kyoto University, Wakasa Bay, 0–1 m, Dec. 9, 1978. C-8: Rocky shores of Dogo Is. and Nishinoshima Is., the Oki Is., 1–8 m, Aug. 6–10, 1981. C-9: Mediolittoral zone of Tsuyazaki, Fukuoka Prefecture, May 17, 1976.

D. Collection made from the mediolittoral zone of vertical wall of moles built at Torigashima Islet, about 500 m off the estuary of the Sendai River, Karo-cho, Tottori Prefecture, Dec., 1977 to Dec., 1978, and placed at my disposal by T. Kuwamura of Chukyo University.

E. Collections deposited at the Fukui City Museum of Natural History, made along the coast of Fukui Prefecture, and offered for identification by T. Kobayashi of the museum. E-1: From the oyster farm off Obama City, Wakasa Bay, by T. Kobayashi, Jan. 27, 1983. E-2: Among the samples dredged off Echizen-cho by H. Tanigawa, Oct. 20, 1969 and Jan. 10, 1977, and by A. Suzuma, Sept. 29, 1968, Oct. 7, 1969, May 21, 1975 and Aug. 15, 1981.

F. Collections deposited at the Osaka Museum of Natural History and offered for identification by R. Yamanishi of the museum. F-1: Off Amino-cho, Kyoto Prefecture, 30–120 m, by G. Kanamura, Aug., 1982. F-2: Tsushima Strait, St. KT 79–8–15, 34°47.6'N and 130°37.1'E, 113–118 m, by H. Ishii, June 11, 1979. F-3: West off the estuary of Kuzuryu River, Fukui Prefecture, 82–86 m, by Y. Morozumi, May 22, 1979.

G. Collections made by T. Imaoka. G-1: Dredged by gill net off Toga and Nyudo-zaki, Oga Peninsula, May 19, 1979. G-2: Mediolittoral zone of Benten-zaki, Uchiura-cho, Ishikawa Prefecture, May 9, 1979. G-3: A shore of Wajima City, Ishikawa Prefecture, 7–9 m, July 23, 1980. G-4: Dredged 8 miles NNE off Kan'murijima Islet, 130–160 m and NW off the islet, 110 m, both in Wakasa Bay, Oct. 9, 1979. G-5: Utani, Hawaii-cho, Tottori Prefecture, 1.5 m, Apr. 15, 1978.

H. Collections made in the vicinity of the Noto Marine Biological Station of Kanazawa University, Tsukumo Bay, Noto Peninsula. H-1: By M. Komatsu of Toyama University, May 8, 1970 and offered for identification to T. Tokioka, and then forwarded to me. H-2: By T. Shin'ya of the station, Apr. 5, 1975. H-3: By H. Michibata of Toyama University, Apr. 7 and May 10, 1981.

I. Collections dredged around Tsukumo Bay by T. Shin'ya and M. Matada of the Noto Marine Biological Station of Kanazawa University. I-1: Off the bay, 15-40 m, June 9, 1975. I-2: In the bay, about 25 m, Mar. 17, 1976.

J. Collections along the coast of Fukui Prefecture. J-1: From the artificial reefs off Kaji, near Mikuni, about 3 m, Mar., 1981, offered for identification by K. Hibino of the Fisheries Experimental Station of the prefecture. J-2: From the artificial reefs off Tateishi, Tsuruga Bay, 50 m, June 16, 1981, and offered for identification by T. Yasuda of the station. J-3: Dredged off Uchiura Bay of Wasaka Bay, 49.2 m, May, 1979 and offered for identification by H. Yokoyama of Kyoto University, and 40 m, June 11, 1980, offered by T. Yasuda. J-4: Dredged near the mouth of Uchiura Bay, about 25 m, July 27, 1977 and offered for identification by H. Yokoyama.

K. Collections dredged off Tsuyazaki, near Fukuoka by T. Kikuchi of Kyushu University. K-1: 7 km off this point, 37 m, May 9, 1961. K-2: 15 km off this point, 62.5 m, July 4, 1975.

L. Miscellaneous collections. L-1: In the mole of the Fisheries Research Station, Kyoto University, Maizuru Bay by T. Kuwamura of Chukyo University, Sept. 6, 1974. L-2: Off Amino-cho, Kyoto Prefecture, about 10 m by S. Fuse of Kyoto University, Oct., 1979. L-3: Off the Cape Hinomisaki, Shimane Prefecture, 15 m by S. Shirai, Aug. 27, 1976, submitted to T. Tokioka for identification, and then forwarded to me. L-4: On the shore of Kokura, Kitakyushu City, Fukuoka Prefecture, 1.5 m by M. Ootani, Apr., 1979. L-5: From the mole set off Kojima-cho, Nanao Harbor, 0-about 4 m by M. Ootani, Mar., 1985. L-6: Samples taken mainly by SCUBA in Tsukumo Bay, Ushitsu, Nanao Bay and Doumi, all located on the eastern coast of Noto Peninsula, 5-10 m by Y. Shirai and K. Yamamoto of Kanazawa Aquarium, 1985-1986. L-7: From the buoys off Asamushi, Mutsu Bay by J. Kobayashi of Mitsubishi-Kasei Institute of Life Sciences, June 19, 1985. L-8: From the rope immersed in the shallow water in front of the Oki Marine Biological Station of Shimane University by K. Tsuneki of the university, Jan. 16, 1985. L-9: From the vertical mole of Kokura Harbor, Kitakyushu City, 1.5 m by M. Ootani, Apr., 1979. L-10: Fukuura, west coast of Noto Peninsula, 5-10 m, on Apr. 19, 1986, by K. Yamamoto of Kanazawa Aquarium. L-11: On the coast of Shimokita Peninsula, Mutsu Bay, 17-18 m by M. Tsuchiya of the University of the Ryukyus, Aug. 30, 1978.

M. Collection around Oga Peninsula, dredged by the R/V "Senshumaru" of the Fisheries Experimental Station of Akita Prefecture, down to 104 m deep, or collected medio- or infralittorally mainly by me; already listed without descriptions by Nishikawa (1984b). For the detailed station data see Nishikawa (1984b, pp. 149-150).

N. Collection dredged by the R/V "Galathea" of the Oki Marine Biological Station of Shimane University, off SW coast of Dogo Is. of the Oki Isls, 30-55 m deep, Sept. 9-12, 1985; already listed without descriptions by Nishikawa (1986b). For detailed station data see Nishikawa (1986b, p. 175).

Part I. Taxonomy

Family Polyclinidae

1. *Polyclinum saturnium* Savigny, 1816

Polyclinum saturnium Savigny, 1816, pp. 190-191, pl. 19, fig. 1.

Material examined: None.

Distribution in Japan Sea. This species is recorded by Rho (1971, 1975) from the

Korean shore facing Korea Strait.

Distribution outside Japan Sea. Osaka Bay (Tokioka, 1962b), west coast of Kii Pen., 3.5 m deep (Nishikawa, 1980b) and Sagami Bay, 80 m deep (Tokioka, 1962b), Japan; Gulf of Suez (Savigny, 1816; Hartmeyer, 1915b; Michaelsen, 1920); Gulf of Aquaba (Van Name, 1952); Red Sea (Michaelsen, 1920).

2. *Polyclinum* sp. aff. *saturnium* Savigny, 1816

(Fig. 1, A-B)

Material examined: A (Toyama Bay): a rounded colony, 24 mm \times 18 mm in extent, 10 mm in height.

Description. Test soft, gelatinous, transparent and slightly pinkish white. The colony surface wholly covered, though never impregnated, with fine sand grains so densely that the zooids cannot be seen; system indistinct, though three common cloacal apertures are discernible. Zooids pale pink. In an expanded zooid, thorax 4.5 mm long; abdomen about half as long as thorax; postabdomen as long as abdomen. Branchial aperture terminal and 6-lobed, while the atrial subterminal and smoothly margined. Atrial languet elongated and phylliform, penetrated through with a pair of muscle bundles each derived from the dorsal-most one of the thoracic bundles on respective sides, branching distally and crossed by many fine muscle fibers. Six to 8 longitudinal muscle bundles on each side of thorax, confined to the anterior part (Fig. 1, A). Tentacles about 20. Ciliated groove as a transverse slit. Fifteen to 16 stigmatal rows, each composed of about 15 stigmata per each side; about the same number of branchial papillae discernible on respective transverse vessels on each side. Anus bi-lobed, opening at the level between 8th and 9th stigmatal rows counted from anterior. Up to 5 embryos found mainly in the right peribranchial cavity. The proximal end of rectum constricted off distinctly from the rear end of mid-gut; a pair of small rectal coeca in some zooids. Gonadal sac contains several eggs proximally, numerous small testicular follicles distally. The larva elliptical in outline, up to 600 μ m in trunk length, provided with 3 attachment processes alternating with 4 median ampullae, 4 pairs of lateral ones, and a number of vesicles on each side along the dorsal edge and in the posteroventral region of trunk (Fig. 1, B).

Remarks. The present specimen conforms well to the original description of *Polyclinum saturnium* given by Savigny (1816) and its subsequent one by Tokioka (1962b), especially in the colony shape, thoracic musculature and the number of stigmatal rows. However, the larva from the present colony from Toyama Bay has 4 pairs of lateral ampullae and, in addition, 4 median ones; in the colonies of *P. saturnium* from Osaka and Sagami Bays, according to the description by Tokioka (1962b), the larvae lack median ampullae. The taxonomic significance of this difference cannot be estimated properly at present. According to Millar (1962a), in *Polyclinum arenosum* Sluiter, 1898 "before the larva is fully developed there are 4 pairs of lateral ampullae-- , but later they subdivide to give rise to 8 pairs". This observation

suggests a possibility that the above-mentioned difference was due merely to an ontogenetic sequence. The present colony is thus treated tentatively as *P. sp. aff. saturnium* until the taxonomic significance of the number and arrangement of larval ampullae in the genus *Polyclinum* is clarified.

The larvae from the present colony, provided with 4 median and 4 pairs of lateral ampullae, are reminiscent of those of *P. macrophyllum* Michaelsen, 1919 recorded from Australia (Kott, 1962, 1972d); but larvae from the colonies collected in Mozambique and identified with this species have only 4 median ampullae (Millar, 1956). The extensive spadeshaped atrial languet of this species, however, is unique, and distinguishes the species from the present colony.

3. *Polyclinum vasculosum* Pizon, 1908

Polyclinum vasculosum Pizon, 1908, pp. 223–227, figs 25–27.

Material examined. D (Tottori): a colony, 18 mm × 20 mm in extent and 4 mm thick collected in Dec. 1977, and two colonies, 17 mm × 17 mm and 2.5 mm, and 8 mm × 6 mm and 1.6 mm in Dec. 1978.

Description. Colony more or less flattened, attached to substratum by its whole underside. Colony surface wholly and densely coated, though never impregnated, with sand grains; system indiscernible. Test very tough, transparent and colorless. Zooids contracted and rather deteriorated; thorax up to about 1.3 mm long, abdomen nearly as long as, or slightly shorter than thorax, and postabdomen to about 0.7 mm long. Thoracic musculature composed of 8 to 10 longitudinal bundles in the anterior half of thorax on each side, the ventral 5 or 6 of which converging to branchial aperture, while the dorsal 3 or 4 to the atrial. About 20 stigmata in each half of 10(?) or 11 stigmatal rows. Gonad partly mature.

Remarks. In the thoracic musculature and the number of stigmatal rows, the present specimens from Tottori conform very well to the previous descriptions of *P. vasculosum*, especially that given by Nishikawa & Tokioka (1976a) on the specimens from Amami.

Recently Kott & Goodbody (1980) synonymized *P. vasculosum* and *P. laxum* Van Name, 1945, with *P. constellatum* Savigny, 1816, while Kott (1981, p. 158) synonymized *P. tsutsuii* with *P. sundaicum* (Sluiter, 1909). On the other hand, Tokioka (1967c) pointed out the remarkable similarity in the zooidal structure between *P. vasculosum* and *P. tsutsuii* Tokioka, 1954; further, he regarded *P. laxum* as a junior synonym of *P. vasculosum*, but distinguished this species clearly from *P. constellatum*. Tokioka (1972) also suggested the possible conspecificity of *P. laxum* and *P. planum* (Ritter et Forsyth, 1917). Thus, many problems in the species identification within the genus *Polyclinum* remain unsettled, as noted by Kott & Goodbody (1980). Hence, the validity of the above-mentioned species may better be kept pending in the present study.

Distribution in Japan Sea. Tottori, 0 m (in the present study).

Distribution outside Japan Sea. Amami Isls (Nishikawa & Tokioka, 1976a); Viet Nam (Tokioka, 1967a); Amboina (Pizon, 1908); Philippines, Mariana and Hawaiian Isls (Tokioka, 1967c).

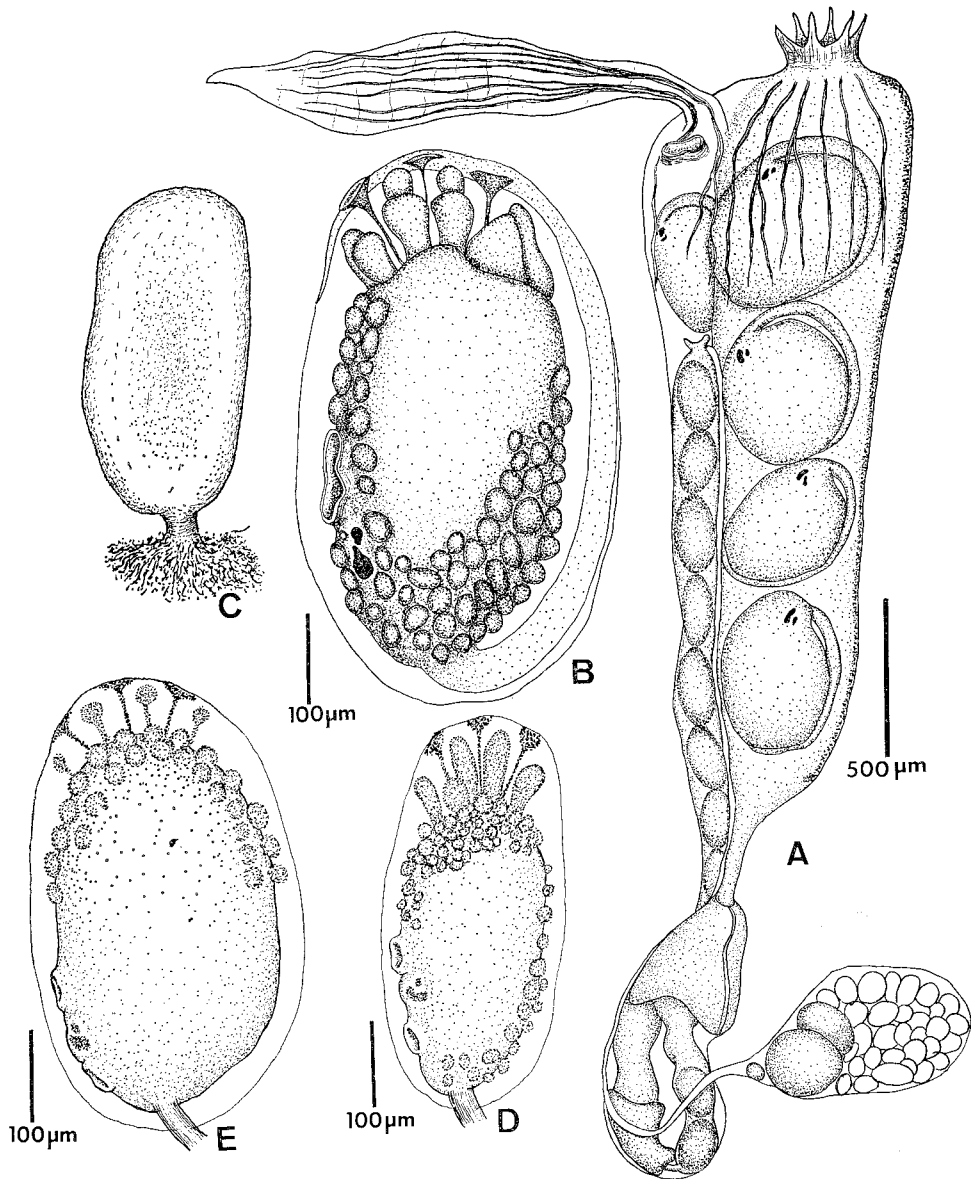


Fig. 1. A-B. *Polyclinum* sp. aff. *saturnium* Savigny from Toyama Bay (Collection A); C. *Polyclinum* sp. cf. *planum* (Ritter et Forsyth) from Wakasa Bay (E-1); D. *Sidneioides japonense* Redikorzev from Tottori (D); E. *Aplidium multiplicatum* Sluiter from Tsuyazaki (C-9). A. right side of zooid; B, D & E. right side of larva; C. 24 mm long colony.

4. *Polyclinum* sp. cf. *planum* (Ritter et Forsyth, 1917)

(Fig. 1, C)

Material examined: E-1 (Wakasa Bay): A single colony.

Description. Colony elongated vertically and laterally flattened, 24 mm long, 16 mm wide, 7 mm thick, attached to substratum by a short stout peduncle issued from the proximal end of colony and distally ramified into a tuft of many fine rooty processes (Fig. 1, C). Numerous zooids, confined to surface layer over the whole colony excepting peduncle. Test in surface layer rather tough, though gelatinous in hypozooidal (=core) area; transparent and colorless in either region, neither coated on surface nor impregnated with sand grains. System indistinct because of deterioration of zooids. Thorax about 2.5 mm long; abdomen and postabdomen much smaller than the thorax. Atrial languet simple and narrow, situated slightly apart from anterior margin of subterminal atrial aperture. Thoracic musculature consists of about 10 short bundles, about 6 ventral ones converging to branchial siphon while the rest to the atrial (and/or languet?); the bundles confined to narrow limited area around anterior end of thorax. Six to 8 embryos in the right peribranchial cavity. About 15 stigmata in each half of 12 or 13 rows; branchial papillae present, but their exact number cannot be counted. Larvae up to 600 μ m in trunk length, provided with 3 attachment processes, 4 median and 4 pairs of lateral ampullae, as well as a number of vesicles roughly arranged in 3 rows in the anterodorsal and postero-ventral regions of each side.

Remarks. The laterally flattened and pedunculate appearance in the present colony may be reminiscent of "pumpkin-seed shaped" (though spherical in smaller) and pedunculate colonies of *P. planum* (Ritter et Forsyth) previously recorded only from California (Ritter & Forsyth, 1917; Van Name, 1945; Fay & Johnson, 1971; Abbott & Newberry, 1980). However, the present specimen seems to differ from *P. planum* of California in the thoracic musculature (confined more closely to the anterior end of thorax in the specimen, but occupying the anterior half of thorax in *P. planum*) and the number of stigmatal rows (12 or 13 in the former, 13 to 17 in the latter). Further, the zooidal arrangement, an important diagnostic character in the species of *Polyclinum*, cannot be determined in the present specimens because of the deterioration of zooids. The exact affiliation of the present colony must be left unstated.

5. *Aplidiopsis pannosum* (Ritter, 1899)*Polyclinum pannosum* Ritter, 1899, p. 519, figs 17-18.*Aplidiopsis pannosum*: Hartmeyer, 1924, p. 187.

For other synonyms see Van Name (1945, p. 66).

Material examined: D (Tottori): two colonies collected in Dec. 1978; 25.5 mm \times 16 mm in extent and 11 mm thick, and 25 mm \times 11 mm and 16 mm.

Description. Colony massive, oval in outline and flattened at the top; attached to substratum by a short and very thick peduncle; wholly coated, though not impregnated, with sand grains. Test rather tough, transparent and colorless. About 13 (in the smaller colony) or 20 (in the larger) oval common cloacal apertures over the colony surface, opening at the tip of low but distinct siphonal elevations. Thorax usually 3.5 mm long, abdomen about half as long as thorax and postabdomen issuing from the left side of the intestinal loop, 2.5 mm or longer. Branchial aperture terminal and 6-lobed, while the atrial subterminal and smooth-margined; a simple elongated atrial languet is found slightly anterior to the anterior margin of the aperture. A small conical projection of mantle wall is always discernible just posterior to the atrial aperture. About 7 to 9 longitudinal muscle bundles on each side of thorax; rather thick anteriorly, but tapering posteriorly into fine fibers. About two dozen stigmata in each half of 14 or 15 rows; the posterior second row not reaching the dorsomedian line in some zooids. No branchial papillae. Tentacles rather long, about 30 in number, comprising larger and smaller ones alternating almost regularly. Ciliated groove as an oval slit. Anus bi-lobed, opening at the level of 8th stigmatal row counted from anterior. Stomach with smooth surface, situated nearly in the middle of abdomen and occupying roughly a quarter of its length. Rectal coeca indiscernible. Gonad empty.

Remarks. From around Japan the following 3 species of *Aplidiopsis* have been recorded: *A. pannosum* (Ritter) (including *A. helenae* Redikorzev, 1927, after Tokioka, 1960a) from subarctic waters (10 to 18 stigmatal rows and 16 to 18 or more stigmata in each half row), *A. amoyense* Tokioka from Amoy, South China (12, and 8 to 12: see Tokioka, 1967c), and *A. tokaraensis* Tokioka from the Tokara Isls, Japan (12 or 13, and 18 to 20: see Tokioka, 1954a), though the last species is suggested by F. Monniot (1974) to belong to the genus *Sidnyum* by the 8-lobed branchial aperture and the musculature of postabdomen. In terms of colony appearance, the number of stigmatal rows and stigmata in each row, and thoracic musculature, the present specimens from Tottori resemble *A. pannosum* very well, and are safely identified with this species. So far as I am aware, the present locality is the southern-most one for this species.

Distribution in Japan Sea. Tottori, 0 m (in the present study).

Distribution outside Japan Sea. Pribilof Isls, Bering Sea (Ritter, 1899: cited from Van Name, 1945); Montague Is., Gulf of Alaska, 15 fms (Van Name, 1945); Tanjaskaja Bay, Northern Okhotsk Sea, 34 m deep and off west coast of Kamchatka, 20 m (Redikorzev, 1927); off west coast of Kamchatka, 66 m (Tokioka, 1960a).

6. *Sidneioides japonense* Redikorzev, 1913

(Fig. 1, D)

Sidneioides japonense Redikorzev, 1913, pp. 210-212, fig. 5.

Material examined: D (Tottori): five colonies collected in Oct. 1977; the maximal 15 mm ×

12 mm in extent and 3.8 mm thick, while the minimal 4 mm \times 5 mm and 4 mm.

Description. Colony more or less flattened; surface wholly and densely coated, though not impregnated, with sand grains. Systems indiscernible except in the smallest colony, where a single common cloacal aperture is encircled by many zooids roughly arranged in a single ring. Thorax 2.5–3 mm, abdomen about 2 mm, postabdomen up to 3.2 mm or more in length. Long atrial languet issuing from mantle nearly midway between branchial and atrial apertures; the tip sometimes serrated. A small conical projection of mantle wall found just behind atrial aperture. Four to 6 rather thick longitudinal muscles on each side of the whole thorax, though much thinner near the posterior end in some zooids. About 24 tentacles; larger and smaller ones alternating. Ciliated groove consisting of an oval opening. About two dozen stigmata in each half of 11 to 14 (rarely 10 or 15) rows. In one thorax with 10 stigmatal rows, the anteriormost row was crossed by a thin parastigmatic vessel. Anus opening nearly at the level of 5th row counted from posterior. Ovary situated along the ventral side of rectum at the level of first to third stigmatal rows on the right side of thorax. About 10 embryos in peribranchial cavity. Postabdomen densely packed with up to 50 testicular follicles. Larva 450 μ m in trunk length and 220 μ m wide, provided with 3 attachment processes and 4 pairs of lateral ampullae, as well as many vesicles anterodorsally and ventrally (Fig. 1, D).

Remarks. The present specimens accord with those of *S. japonense* previously described by Redikorzev (1913), Tokioka (1953c) and Millar (1975), except having rather fewer longitudinal thoracic muscles (4 to 6, instead of 6 to 12 in the latter). This feature may be reminiscent of *S. snamoti* (Oka) with "about a half of dozen" of them (Tokioka, 1953c, p. 177). The present specimens, however, may better be identified with *S. japonense* because they have fewer stigmatal rows (see below).

Distribution in Japan Sea. Tottori (in the present study).

Distribution outside Japan Sea. Sagami Bay (Tokioka, 1953c); Shimoda, Izu Pen. (Nishikawa, 1982b); Usa, Kochi Pref. (Nakauchi, 1973); Nagasaki (Redikorzev, 1913); Banda Sea, 25 m deep (Millar, 1975).

7. *Sidneioides snamoti* (Oka, 1927)

Polyclinum snamoti Oka, 1927e, p. 500, fig 964.

Sidneioides snamoti: Tokioka, 1953c, pp. 177–178, pl. 7, figs 2–7.

Material examined: None.

Remarks. The occurrence of this species in the Japan Sea has been recorded only by Rho (1971, 1975) from the eastern waters of Korea. This species was reported to have 17 to 19 stigmatal rows by Tokioka (1953c). However, Rho's specimens have 15 to 18 rows and this seems to show an intermediate feature between the probably more typical *S. snamoti* and *S. japonense*, the latter having 10–16 rows (see above; and Nishikawa, 1982b). Further, the number of longitudinal muscle

bundles on the thorax appears not to be a good diagnostic character discriminating these two species (see the remarks of *S. japonense* above). Consequently, these two species might better be treated as conspecific, as suggested by Millar (1975). On the other hand, according to Nakauchi (1973), these two species seem to inhabit different areas in the region of Usa in Tosa Bay; *S. japonense* occurs "common at protected places on the rocky shore" facing the open sea, while *S. snamoti* is found "common at the mouth of the inlet (=Uranouchi Bay)". Moreover, the descriptions of these two species in the same collection from Sagami Bay seem to show some differences in features of the colony other than those in zooidal structure (Tokioka, 1953c). Thus, these two species are here treated as distinct from each other, while this treatment should be examined on more materials by future studies.

Distribution outside Japan Sea. Sagami Bay (Tokioka, 1953c); Usa, Kochi Pref. (Nakauchi, 1973, 1974).

Genus *Aplidium*

After a consideration on the previous discussions regarding the validity of the genera *Aplidium* and *Amaroucium*, I came to the conclusion that these two genera may be united into a single genus *Aplidium*, as has been recently done by most ascidian taxonomists.

Savigny (1816) established a new genus *Aplidium* for six species, five new ones and an already known *Alcyonium ficus* Pallas, defining it as having no "cavité centrale" (=common cloacal cavity); this definition remained accepted as late as 1912 by Alder & Hancock (p. 22), but erroneously so as indicated in 1886 by Herdman (see below). When Savigny established the genus *Aplidium*, he proposed two groups within this genus, on the basis of the relative length of postabdomen, either shorter or longer than the rest of the zooid. To the "shorter" group *A. lobatum*, *A. ficus* and *A. tremulum* were assigned, while to the "longer" group *A. effusum*, *A. gibbulosum* and *A. caliculatum* were allotted. As Savigny (1816) didn't fix the type species for the genus *Aplidium*, Hartmeyer (1915a) regarded *A. zostericola* Giard, 1872 as its type species. This treatment, however, is obviously wrong in view of Articles 67g and 69a of the International Code of Zoological Nomenclature (3rd ed.), because *A. zostericola* was published after the establishment of this genus. Michaelsen (1920) may be the first to correctly designate *A. lobatum* as the type species but without any remarks, followed by subsequent authors. The species in the "shorter" group are provided with testicular follicles packed into an irregularly arranged mass, while those of the "longer" group have follicles arranged serially. According to the illustrations given by Savigny (plates 16-17), in *A. lobatum*, *A. tremulum*, *A. effusum* and *A. caliculatum* the zooid is clearly shown to bear the short atrial languet. Later, Milne Edwards (1841) encountered many specimens assignable to Savigny's *Aplidium*, except that they have well-ramified common cloacal cavities. For these he established a new genus *Amaroucium* on the basis of the existence of common cloacal cavities and included in it four new species, i.e. *A. proliferum* (type species of the genus

by subsequent designation by Hartmeyer (1915a)), *A. albicans*, *A. argus* and *A. nordmanni*. As correctly pointed out by Herdman (1886), however, "it is very probable that -- the apparent absence of common cloacal cavities in (Savigny's) spirit-specimens is a result of contraction after death, and that Savigny's species of *Aplidium* really had the cavities, and therefore Milne-Edwards' *Amaroucium* was unnecessary and is merely a synonym of *Aplidium*". Nevertheless, these two taxa were redefined by Herdman himself (1886) as those of a full-generic rank, distinguished from each other by not single characters but a combination of colony shape, length of zooid, relative position of atrial aperture, presence or absence of atrial languet and relative length of postabdomen.

Since then references have been made by many researchers to the diagnostic characters to distinguish these two genera. The characters are extensively enumerated by Van Name (1945). On the basis of these diagnostic characters, however, comparing "forty species variously assigned to *Aplidium* and *Amaroucium*, taking details from published account", Millar (1960) came to the conclusion "that there is no generic distinction to make within the group, -- adopting for all species the generic name *Aplidium*, which has priority over *Amaroucium*". This conclusion has been accepted by the majority of ascidian taxonomists, and I also follow it. However, this does not necessarily mean a complete denial of the possibility that there may be two or more different clades within the genus *Aplidium* thus lumped. This genus now comprises more than two hundred species inclusive of more or less uncertain ones (see Nishikawa, 1986c), representing one of the largest genera among the ascidians. Further taxonomic revision of this genus is required to make clear the evolutionary differentiation within.

In this respect, as already suggested by Pérès (1956), Millar (loc. cit.; but also see 1962b) and Nakauchi (1970), the mode of budding may be another diagnostic character to distinguish at least some species from others. In *Aplidium*, two types of budding are recognized (Nakauchi, 1982), i.e., strobilation of the abdomen only (Type I), and strobilation of both the abdomen and postabdomen (Type II). In Table 1, several characters are compared among 8 species already assigned to either type of budding to evaluate the taxonomic significance of these budding types. Colony appearance is excluded from the characters, because it is variable even within a species and, moreover, in all 8 species under consideration the colony is attached to the substratum by the broader part of colony and never capitate. It appears that only the number of stigmatal rows in the blastozooids of later generations may be correlated with budding type; budding of Type I seems to be associated with fewer stigmatal rows (the lowest number being 5 even in the blastozooids of later generations). The dependability of this tendency can be judged when the mode of budding is examined in many other species of *Aplidium*. On the other hand, the table shows that both *A. multiplicatum* and *A. californicum*, which lack median ampullae in the larva and belong to Type II of budding, are more closely related to *A. pallidum* and *A. yamazii* of Type I of budding, rather than to *A. pliciferum* and *A. nordmanni* of Type II. If taxonomic weight is to be placed upon larval morphology, it is to be

Table 1. Some characters in 8 species of the genus *Aplidium* compiled from various published data. (1) Type of budding, for codes see text. (2) Number of stigmatal rows; apparently exclusively in blastozooids of later generations, but never the first generation that are generally furnished with only 4 stigmatal rows (see the text). (3) Number of stomach plications. (4) Atrial languet, its presence represented by (+), while the absence by (—). (5) Maximum length of postabdomen, v. means very, r. rather, s. short and l. long. (6) Arrangement of testicular follicles, clustered (C) or serial (S). (7) Number of ampullae (A's) and vesicles (V's) in fully grown larvae. (Larval trunk length). (8) Locality.

Characters	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<i>petrense</i>	I	5-7	22-24	+	v.s.	C	unknown	SW Indian
<i>pallidum</i>	I	5-8	10-12	—	r.l.	C-S	6-8 V's on each side of the base of AP (420 μ m)	Arctic & N. Atlantic
<i>yamazii</i>	I	5	9-12	—	r.l.	S	ca. 18 V's on each side of the base of AP (560 μ m)	Southern Japan; Ponape
<i>constellatum</i>	II	10-13	15-25	+	v.l.	S	many V's anteriorly (700-800 μ m)	Atlantic coast of N. & Central America; Pacific coast of Costa Rica; N. Japan?
<i>multiplicatum</i>	II	7-11	14-35	+	r.l.	C?-S	up to 33 A's or V's around the base of AP (450-1000 μ m or more)	W. Pacific
<i>californicum</i>	II	8-12	12-23	+	r.l.	S	unknown	NE Pacific
<i>pliciferum</i>	II	8-15	18-32	+	v.l.	S	2-4 median A's & many V's anteriorly (800 μ m)	W. Pacific
<i>nordmanni</i>	II	9-13	30	+	r.l.	S	3 median A's & numerous V's anteriorly (1000 μ m)	Europe
<i>solidum</i>	II	13-15	8	+	r.l.	S	unknown	California

supposed that different types of budding may occur in respective species regardless of their clades, as suggested by Millar (1962b). Occurrence of so much variability in asexual reproduction of botryllids and polystyelids, also lends support to this supposition.

8. *Aplidium spitzbergense* Hartmeyer, 1903

Aplidium spitzbergense Hartmeyer, 1903, p. 341, pl. 6, fig. 14, pl. 13, fig. 17.

For synonyms and references see Van Name (1945, pp. 30-31).

Material examined: None.

Remarks. The occurrence of this species in the Japan Sea is recorded only by Skalkin (1958) from the west coast of South Sakhalin. This species is characterized by having the branchial sac with only 4 stigmatal rows and the stomach furnished with fewer (4 or 5) plications on the surface. According to Nakauchi (1982, p. 757), in all the observed species of *Aplidium* the oozoid is provided with only 4 stigmatal rows. If this is the case also in *A. spitzbergense*, the number of stigmatal rows is considered remaining unchanged during subsequent asexual generations, in contrast to the majority of other species of this genus or other polyclinids, in which the stigmatal rows increase in number during the asexual generations. A species group with 4 stigmatal rows even in the blastozooids of later generations might be distinguishable taxonomically within the genus *Aplidium* from other species group. So far, to the *spitzbergense* species group the following three species are assignable: *A. distomoides* (Herdman), *A. quadriversum* Millar and *A. solum* Monniot et Monniot.

Distribution outside Japan Sea. "The arctic and boreal waters of both hemispheres" (Van Name, 1945,) inclusive of the Bering Sea, 277 fms (Tokioka, 1967c).

9. *Aplidium yezoense* Tokioka, 1967

Aplidium yezoense Tokioka, 1967c, pp. 28–30, fig. 4.

Material examined: None.

Remarks. This species has been recorded only from Hakodate (Tokioka, 1967c).

10. *Aplidium sagamiense* (Tokioka, 1967)

Amaroucium sagamiense Tokioka, 1967c, p. 40 (ref.); Nishikawa, 1980b, tab. 1; 1984b, p. 150.

Amaroucium multiplicatum: Tokioka, 1953c, pp. 180–181, pl. 5, figs 1–4; 1954c, p. 76, pl. 5, fig. 1;

Rho, 1975, p. 125, pl. 1, figs 1–4.

Aplidium octoversum Millar, 1975, pp. 249–252, fig. 36. New Synonymy.

Material examined: C-2 (Mutsu Bay): from buoys of net cages off Moura, several meters deep; a larger colony, 9 mm × 9 mm in area and about 3 mm thick, and 2 smaller ones. C-8 (Oki): Chinza-ki, Nishinoshima Is., 1–6 m; a colony, 9 mm × 4 mm in area and 1 mm thick. D (Tottori): A colony collected in Aug. 1978; 30 mm × 9 mm and 1 mm. M (Oga): from buoys of net cages off Toga; the largest colony, 45 mm × 35 mm and up to 10 mm, and many other smaller ones attached to *Mytilus galloprovincialis*, *Styela clava* and other fouling organisms.

Description. Colony flat or roundish, never pedunculate; elongate oval or irregular in outline. Test soft but tough, nearly transparent and pale orange to white; impregnated sparsely with shell fragments and sand grains only in the colony from D in the present material. In a well extended zooid, thorax up to 1.5 mm, abdomen 1 mm, postabdomen 2 mm or more in length; in some seemingly well relaxed zooids, however, postabdomen may be more or less shorter than abdomen. A simple atrial languet on the anterior margin of atrial aperture. About 10 to 12 stigmata in each half of 6 or 7 (in zooids from the colony of material C-8), 7 or 8 (very

rarely 4 or 5; in those from the colony of C-2), or 8 (in those from M) stigmal rows, while there are about 8 stigmata in each half of 6 rows in those from the colony from D. Stomach plications 10 to 12 in zooids from material C-2, 10 to 14 (12 on an average) in those of C-8, 12 to 14 in those from D or 14 to 15 in those from M. A pair of rectal coeca conspicuous or indistinct. About 8 embryos in the peribranchial cavity in zooids from M. Gonad mature in zooids from M; 2 to 4 ovarian eggs, up to 250 μ m in diameter just posterior to the intestinal loop, while 20 to 30 testicular follicles, arranged behind the eggs rather serially. The larva 250 μ m in trunk length, anteriorly provided with 3 attachment processes and numerous small vesicles; ampullae unclear.

Remarks. In terms of colony structure, existence of atrial languet, number of stigmal rows and that of stomach plications, the present specimens from the Japan Sea conform well to the previous description of the specimen collected from Sagami Bay and referred to *A. multiplicatum* by Tokioka (1953c), which was later (1967c) newly named as *A. sagamiense*, and also to that of the specimens from Osaka Bay and identified with *A. multiplicatum* by Tokioka (1954c). The only exception is that some zooids in the present specimens are provided with only 6 stigmal rows, instead of 7 or 8 rows recorded in the previous descriptions. I believe that this difference is an intraspecific variation; six being the lowest number of stigmal rows in this species.

The specimens collected from the western waters of Korea and referred to *A. multiplicatum* by Rho (1975) is safely synonymized with *A. sagamiense* thus defined because of the remarkable similarity in many important features. In the Korean specimens, the number of stigmal rows is 6 (rarely up to 9) and stomach plications seem to number slightly over a dozen judging from her figure 2 of plate 1. The larval trunk is reportedly as long as 860 μ m, much larger than the 530 μ m maximum of Japanese specimens. However, it is only about 500 μ m, when her Fig. 4 of Plate 1 is measured at the indicated scale; Rho's description of larval structure closely resembles that of Tokioka's specimen (1953c) shown in his Fig. 4 of Plate 5. Further, *A. sagamiense* is related closely to *A. octoversum* Millar collected off Kyushu, Japan (33°18'26"N and 129°19'48"E), 64 m deep (Millar, 1975). This latter was reported to have been encrusting, with an atrial languet, provided with 8 stigmal rows and 10 to 12 stomach plications, and bearing larva about 500 μ m in trunk length with many vesicles around 3 attachment processes. Millar's species seems to fall in the variation range of *A. sagamiense* and the former is here treated as a junior synonym of the latter.

The existence of 6 stigmal rows and 10 to 14 stomach plications in some colonies of the present material may be reminiscent of *A. monotonicum* (Tokioka, 1954) previously found from Tanabe Bay and the Tokara Isls of Japan, which bears 6 stigmal rows and 13 to 18 (or sometimes up to 20) stomach plications (Tokioka, 1954a; Nishikawa, unpublished data), and *A. depressum* Sluiter, 1909 from the Philippines, Fiji and Hong Kong, that has 6 to 8 stigmal rows and 12 stomach plications (Van

Name, 1918; Kott, 1981; Kott & Goodbody, 1980). In *A. monotonicum*, however, colonies are much smaller (up to 3 mm in diameter), each containing only 3 to 12 zooids surrounding a single common cloacal aperture at the center. The thorax is beautifully colored orange to red when alive; all these features are never shared with the present colonies of *A. sagamiense*. Further, these are clearly distinguishable from *A. depressum* that completely lacks an atrial languet.

Distribution in Japan Sea. In the present study, this species was collected from Mutsu Bay, Oga Pen., Oki Isls, 1–6 m deep, and Tottori, 0 m; in addition to these a record from Oga Pen. (Nishikawa, 1984b).

Distribution outside Japan Sea. Sagami Bay (Tokioka, 1953c); Sakushima Is., Atsumi Bay (Nishikawa, unpublished data); Ise Bay, bottom (do.); Sugashima Is., Ise Bay, 0 m (Nishikawa, 1980b); Ago Bay, several meters (Nishikawa, unpublished data); Osaka Bay (Tokioka, 1954c; Nishikawa, unpublished data); off Kyushu, 64 m (Millar, 1975); western waters of Korea (Rho, 1975).

11. *Aplidium multiplicatum* Sluiter, 1909

(Fig. 1, E & Table 2)

Aplidium multiplicatum Sluiter, 1909, p. 101, pl. 5, fig. 5.

Material examined: B (Mutsu Bay): No. 10(S316), a single colony, 4 mm×5 mm in area and 3 mm thick, collected by Hozawa in front of Enmushubi-jizo, near the Asamushi Marine Biological Station on Aug. 23, 1926; No. 236 (part), an oozoid, by Hozawa and Ito from the same locality on July 14, 1926. C-9 (Kyushu): two colonies, 30 mm×10 mm and 26 mm×15 mm in extent, respectively, and about 7.5 mm thick. D (Tottori): two colonies collected in Dec., 1978, 11 mm×7.2 mm and 9.8 mm×7.3 mm in extent, and about 2 mm thick.

Description. Colony encrusting, roundish or rather massive, never pedunculate, furnished with no foreign matter except in the colonies from Tottori in which test surface is coated densely, but never impregnated, with sand grains. Test soft but rather tough, or in some colonies somewhat gelatinous, transparent to translucent, and pure or slightly pinkish white. Zooids rather contracted and deteriorated; thorax up to 1.3 mm, abdomen to 1 mm long, while postabdomen of various lengths. Atrial languet simple or trifid issuing from the anterior margin of atrial aperture situated subterminally. About 12 fine longitudinal muscles on each side of thorax. Several embryos in the right peribranchial cavity of zooids in colonies from Kyushu. About 10 papillae in the tentacular ring in one zooid. Meristic characters in the branchial sac and stomach are shown in Table 2. Gonad matured only in the zooids from Kyushu; many testicular follicles arranged roughly serially. The larva 480 μ m in trunk length; 4 median ampullae alternating with 3 attachment processes; many vesicles arranged on each side of the anterior half of trunk roughly in double rows along the midline (Fig. 1, E).

An oozoid is found in the present material B, attached to a pebble by the abdominal part with thorax upright, and enclothed with transparent test. Thorax 1.4 mm, abdomen 1 mm in length and postabdomen nearly as long as abdomen;

Table 2. Characteristics of the specimens referred to *Aplidium multiplicatum* Sluiter from different localities.

Locality (Depth)	Number of		Length of larval trunk (μ m)	Author
	stigmatal rows (stigmata per half row)	stomach plications		
Indonesia (22–36 m)	7 (10)	ca. 18	unknown	Sluiter, 1909
Indonesia (1–20 m)	8–10	16–20	unknown	Millar, 1975
Philippines (23–29 fms)	9–10 (14–16)	18–20	unknown	Van Name, 1918
Palau & Gilbert Isls (0–20 fms)	7–10 (10–30)	20–35	up to 1100	Tokioka, 1967c
Truk, Ponape & Majuro (0–13 m)	7–10	ca. 24	unknown	Nishikawa, 1984a
Queensland, Australia	6–7 (8)	14–18	450	Kott, 1963
Hong Kong (5–15 m)	9 (15)	14	unknown	Kott & Goodbody, 1980
Amami Isls (0 m)	8 (15–24)	ca. 20	960	Nishikawa & Tokioka, 1976a
Misaki	7–8 (ca. 8)	20–25	825	Tokioka, 1953c
Tsuyazaki, Kyushu (0 m)	8–11 (ca. 10)	15–18	480	present study
Tottori (0 m)	7–8 (ca. 10)	ca. 20	unknown	present study
Mutsu Bay (0? m)	10	ca. 25	unknown	present study
India	6–8 (16–18)	20–30	unknown	Renganathan & Monniot, 1984

a dozen longitudinal muscles on each side of thorax; about 12 or more stigmata in each half of 4 rows. About 24 stomach plications; a pair of rectal coeca distinctly discerned.

Remarks. The present specimens from the Japan Sea conform very well to the previous descriptions of *A. multiplicatum* based on the specimens outside the sea (for references see Table 2), differing in that the larva is provided with median ampullae only in the Japan Sea specimens, so far as the previous descriptions have necessary information as to the ampullae. The taxonomic significance of this difference is still an open question.

In colonies collected from NW Australia and referred to *A. multiplicatum* with some doubt by Millar (1963), zooids are provided with 8 stigmatal rows and 21 stomach plications, but the atrial aperture opens "on a tubular siphon with no lappet", and the larva is furnished with 4 pairs of ampullae but no vesicles. The difference between Millar's specimens from Australia and the other ones of *A. multiplicatum* in the atrial languet as well as in the larval structure is significant. Therefore, Millar's record is excluded here from the synonymy of this species.

As can be seen in Table 2, which compares the characters of *A. multiplicatum* with those of *A. sagamiense* described above, these two species are barely distinguish-

shable from each other in some characters. Crucial comparisons may be expected in future among these two species and also several other related ones including *A. californicum* (Ritter et Forsyth); its conspecificity with *A. multiplicatum* is already suggested by Tokioka (1967c; but also see Kott & Goodbody, 1980; Nakauchi, 1987).

Distribution in Japan Sea. In the present study, this species was collected from Mutsu Bay, Tottori, and Tsuyazaki, Fukuoka Pref., 0 m.

Distribution outside Japan Sea. See Table 2; and additionally, Shimoda (Nishikawa, 1982b); Kii Pen., 0–5 m (Nishikawa, 1980b); Seto Inland Sea (Nishikawa, unpublished data); Usa, Kochi Pref. (Nakauchi, 1973); Yoron Is., 2 m (Nishikawa, unpublished data).

12. *Aplidium rhabdocormi* n. sp.

(Fig. 2)

Type series. Holotype, 45 mm long colony in the material A, dredged by the Tansei-maru from Toyama Bay, 37°26.9'N and 137°44.2'E, 1380–1410 m deep, on June 3, 1975, and deposited at the Seto Marine Biological Laboratory of Kyoto University (SMBL Type No. 346). Paratypes: a 29 mm long colony in the material A, dredged at the same station as the holotype, and deposited at the National Science Museum (Natural History), Tokyo (NSMT-Pc 1096); a 72 mm long one in the material B, dredged by I. Imai off the port Kamo, Nishitagawa, Yamagata Pref., on Sept. 21, 1931, and deposited at the Oka Collection of the University of Tsukuba (OCUT No. 220); and a 87 mm long one in the material B, dredged off Shimane Pref. in Dec., 1924, labeled by Oka as *Rhabdocormus simanensis* and registered as OCUT No. N23 (S270).

Description. The colony consists of an elongate cylindrical body and more or less slender stalk branched distally into several to many short rooty processes of test carrying some sand grains (Fig. 2, A). Body region is 28 mm long and up to 6 mm in diameter in the holotype, 24 mm long and 9 mm in diameter in a paratype from Toyama Bay, 46 mm and 14 mm respectively in that from Yamagata, and 55 mm and 11 mm in that from Shimane; stalk 17 mm long and 3 mm thick in the holotype, 5 mm long and 3 mm thick in a paratype from Toyama Bay, 26 mm and 4 mm in that from Yamagata, and 32 mm and 6 mm in that from Shimane. Anterior part of body region more or less deteriorated. Test soft, gelatinous and nearly transparent in body, while rather hardened, translucent and white in stalk; test surface sprinkled with mud. About 250 zooids embedded densely and almost evenly in the test only in body region in the colonies from Toyama Bay, though the exact number of zooids is unknown in the other two colonies because of deterioration. Branchial apertures are found to open evenly over the whole surface of body region, while its axial core, as well as the whole stalk, contains only much elongated post-abdominal extensions; common cloacal aperture(s) indiscernible. Cloacal system is obscure, but in the colony from Shimane, rather spacious cavities are found between superficial layer containing (at least the main part of) zooids and axial core. These spacious cavities might possibly be an artifact, because the present colony had already been cut longitudinally in the anterior half of body region when I reexamined them. Unfavourable conditions of zooids prevented my study to ascertain

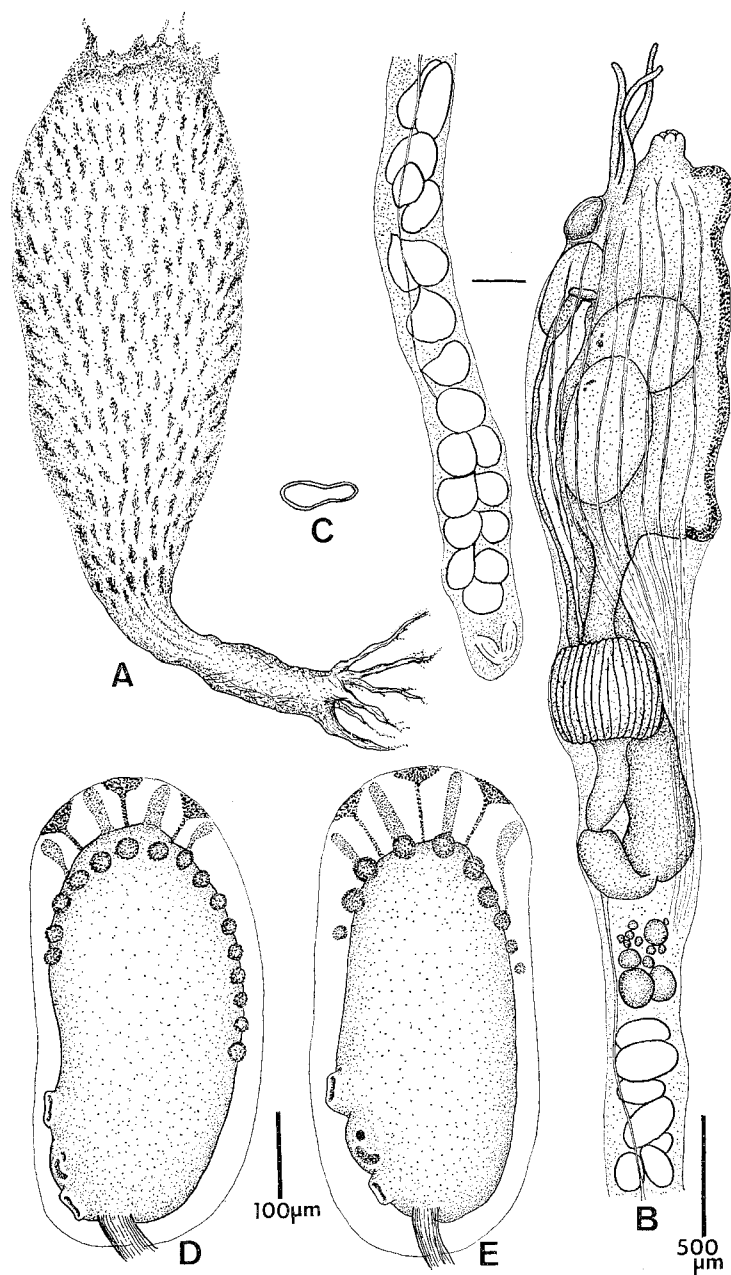


Fig. 2. *Aplidium rhabdocormi* n. sp. A-D, holotype (SMBL Type No. 346) from Toyama Bay (Collection A); E, paratype from Shimane Prefecture (Collection B, OCUT No. N23 (S270)). A, colony, 28 mm long body with 17 mm long stalk; B, right side of zooid; C, ciliated groove; D-E, right side of larva.

whether or not the atrial apertures actually open into the cavities in question.

Thorax 1 to 2 mm and abdomen 1 to 1.5 mm long; postabdomen 1.5 to 3 mm, or sometimes up to 6.5 mm or longer. Eight to 10 longitudinal muscles on each side of thorax, uniting into a single fascicle on respective sides of abdomen and postabdomen. Branchial aperture terminal and 6-lobed, while the atrial subterminal, opening at the level of second or third stigmatal row counted from anterior and provided with a simple, bifid or trifid atrial languet on anterior margin of or slightly anterior to the aperture. About 10 or 12 tentacles; ciliated groove as an oval slit elongated longitudinally (Fig. 2, C). Dorsal languets displaced from dorsomedian line to the left side for the distance of about 2 stigmata. Six to 8 stigmata in each half of 9 to 11 (usually 10) rows in the colonies from Toyama Bay, while about 8 stigmata in each half of 10 or 11 rows in the other two colonies. Anus plainly margined, opening nearly at the level of fifth stigmatal row in well-preserved zooids. Stomach occupies roughly the middle one-third of abdomen; 24 longitudinal plications, some of which may be incomplete. No rectal coeca; mid-gut is distinct. Ovary situated just posterior to alimentary tract; ovarian eggs up to 200 μ m in diameter. Eighteen to 40 testicular follicles arranged roughly in double rows.

Several (up to 5 in holotype colony or to 8 in paratype ones) embryos or larvae in right peribranchial cavity in many zooids. Larval trunk elongated oval in outline, up to 550 μ m long in the colony from Shimane, while up to 625 μ m in the other 3 colonies; with 3 attachment processes and 4 median ampullae, and with about 10 (in the colony from Shimane) or 14 to 16 (in the others) round vesicles arranged in a single row on each side (Fig. 2, D-E). Two pigment spots, the larger posterior one reddish brown and the smaller anterior one black.

Remarks. Although in many *Aplidium* species colonies may be capitate, club-shaped, or more or less pedunculate forms, they are known to comprise the body region from which the slender stalk separated off distinctly only in a very few species as follows: *A. bolteniforme* (Carter, 1885) recorded from SE Australia with 17 to 18 stigmatal rows and 9 to 12 stomach plications (Hartmeyer, 1922), *A. circulatum* (Hartmeyer, 1912) from South Africa, 2 to 4 m deep with 14 rows and 24 plications (Millar, 1955), *A. colelloides* (Herdman, 1886) from South Africa and South Australia, 18 to 72 m with 9 to 18 rows and 12 to 15 plications (Millar, 1962a; Kott, 1972a, 1972b) and *A. gilvum* Millar, 1982 from New Zealand, 60 to 73 m with 11 or 12 rows and 5 plications (Millar, 1982b). Among these species, *A. bolteniforme* has the body region that is oblong in outline and compressed laterally, while the others have oval to spherical bodies. In the present colonies from the Japan Sea, this region is cylindrical. The present specimens may be different from these four species also in the number of stigmatal rows and stomach plications. Thus, the present specimens are regarded as a new species, to which the specific name *rhabdocormi* is proposed after the unique appearance of the colony, suggested by Oka's unavailable generic name.

Description of a colony from Kagoshima. A colony that is similar to this new species in external appearance was offered to me by T. Imaoka for identification. The

colony was dredged off the western coast of Satsuma Pen., Kagoshima Pref., 31°26' N and 129°52' E, 300 to 330 m deep, on Nov. 20, 1977. It consists of a cylindrical body, 45 mm long and up to 10 mm in diameter, and a 6 mm long stalk (seemingly leaving its stump part behind). About 300 zooids in body region; system indiscernible. Test rather gelatinous but not fragile and transparent, containing very dense minute spherical bodies, less than 10 μ m in diameter; impregnated sparsely with sand grains exclusively in stalk. Thorax about 1.3 mm, abdomen 0.6 mm and postabdomen 3.7 mm or longer. Branchial aperture terminal and 6-lobed, though rarely 8-lobed, while atrial aperture is subterminal or opens at the level of 4th or 5th stigmatal row counted from anterior. Atrial languet simple or bifid, issuing from the mantle just anterior to atrial siphon which is short but always distinct. Twelve longitudinal muscles on each side of thorax. Twelve tentacles, the larger and smaller ones alternating. Ciliated groove a round orifice. About six stigmata in each half of 10 rows. Anus bilobed, opening at the level between 8th and 9th stigmatal rows. Twenty-two stomach plications; no rectal coeca. Gonad nearly empty. A single larva in the right peribranchial cavity in very few zooids; larva 600 μ m in trunk length, provided anteriorly with 4 median ampullae alternating with 3 attachment processes, as well as about 10 vesicles in a single row on each side. The present colony from Kagoshima is somewhat different from *A. rhabdocormi* defined above, especially in the rare occurrence of 8-lobed branchial aperture and the lower position of anus in the former. However, so striking are the similarities between these two in colony shape and general features of zooids and larva that the colony from Kagoshima is assignable to this species.

Distribution in Japan Sea. In the present study, this species was recorded off Yamagata, Toyama Bay at a depth of 1380–1410 m, and off Shimane.

Distribution outside Japan Sea. Off the western coast of Kagoshima, 300–330 m (in the present study).

13. *Aplidium constellatum* (Verrill, 1871)

Amaroucium constellatum Verrill, 1871b, p. 359.

Aplidium constellatum: F. Monniot, 1983b, pp. 414–416, fig. 1, B.

For other synonyms see Van Name (1945, pp. 38–40).

Material examined: None.

Remarks. This species has previously been recorded in the Japan Sea only once by Tokioka (1967c) from Hakodate, Tsugaru Strait. In his colony, the zooid had 13 stigmatal rows and about 25 stomach plications; in these figures Tokioka's specimen is more similar to *A. pliciferum* (see below) than to *A. constellatum*. In the colony from Hakodate, however, test surface was "irregularly elevated and depressed"; this remarkable feature is not shared by *A. pliciferum*. *A. constellatum* has so far been known from the Atlantic subarctic to subtropical waters of USA (Van Name, 1945), the Caribbean Sea (F. Monniot, 1983b) and the Pacific coast of Costa Rica (Tokioka, 1972), but also from Hakodate as mentioned above and Akkeshi, Pacific

coast of Hokkaido (Tokioa, 1951a).

14. *Aplidium pliciferum* (Redikorzev, 1927)

(Table 3)

Amaroucium pliciferum Redikorzev, 1927, pp. 387-389, figs 9-10.

Aplidium pliciferum: Kott, 1963, pp. 106-107, fig. 20.

Material examined: B: No 182 (S347), labeled by Oka as *Macroclinum insigne*, a colony (probably half of originally hemispherical colony), 26 mm × 8 mm in extent and up to 12 mm thick, collected by Hozawa, Takatsuki and Sato near Ooma, NW end of Shimokita Pen., facing the Tsugaru Strait, on Aug. 18, 1927; No. 233 (S322), labeled by Oka as *Amaroucium hemisphaericum*, a single colony, 35 mm × 8 mm and about 10 mm thick, collected by Hozawa and Takatsuki on the east coast of Yunoshima Is., off Asamushi, Mutsu Bay, on Aug. 8, 1926. C-1 (Hokkaido): 14 colonies, the largest is 38 mm × 28 mm and 12 mm, from the undersurface or sides of boulders in tide pools, down to 0.3 m deep, at Kutsugata-misaki, Rishiri Is.; 4 colonies, 26 mm × 21 mm in extent and 10 mm thick in the largest, Chazu, Bikuni, 3-5 m deep; a colony, 17 mm × 8 mm and 6 mm, Yobetsu, 1-3 m. C-6 (Noto): 5 colonies, 28 mm × 23 mm and 13 mm in the largest, from undersurface of boulders or stems of *Sargassum* sp. E-2 (Fukui): a colony, 45 mm × 12 mm and 41 mm, zooids much deteriorated and hard to examine, present identification based merely on the massive appearance of the colony. G-2 (Ishikawa): 11 colonies, the largest being 42.5 mm × 15.3 mm and 9.5 mm thick.

Description. Colony roundish, attached to substratum by nearly the whole undersurface. In life, test is white or slightly yellowish, zooids orange to reddish orange, sometimes with yellowish pigment gathered around each branchial aperture and the tips of atrial languet. Test more or less tough, but not hard, semitransparent to translucent and white; surface elevated slightly or markedly between systems or sometimes nearly smooth, and usually devoid of any foreign matter. Zooids up to 10 mm or longer; thorax 2 to 3.5 mm, abdomen 1 to 2.5 mm and postabdomen 1 to 6 mm or longer. Some features of zooids from the colonies of the present material are shown in Table 3. Atrial languet trifid, borne on anterior border of atrial aperture. About 12 tentacles; ciliated groove as a transversely elongated, oval slit elongated transversely. Stomach occupying roughly middle one-third of abdomen; respective longitudinal plications over the stomach surface broken, though rarely, into several pieces. Ovarian eggs up to 250 μ m in diameter; testicular follicles arranged roughly in double rows. Up to 6 to 10 embryos in the right peribranchial cavity; larva with many small vesicles arranged in several rows anterodorsally and ventrally along each side of midline. In the colonies from Rishiri Is., number of stigmal rows seems to be correlated positively with colony size:

Area of colony	Number of stigmal rows (mode)
6 mm × 4 mm	6-10 (7)
5 × 4	9-10 (9)
12 × 7	10-11 (11)
22 × 13	10-12 (12)
34 × 25	11-13 (12)
38 × 28	12-15 (13)

Table 3. Characteristics of specimens referred to as *Aplidium pliciferum*.

Locality (Depth)	Number of						Rectal coeca	Larval trunk length (μ m)	Author
	stigmatal rows	stigmata in each half row	stomach plications	longitudinal muscles on each side of thorax	testicular follicles	larval median ampullae			
Rishiri (0–0.3 m)	6–15*	10–15	24–30	ca. 12	60 or more	—	present	—	present study
Bikuni (3–5 m)	14–15	ca. 15	24	ca. 12	50 or more	4	present	750	present study
Yobetsu (1–3 m)	ca. 10–12	—	24 or more	ca. 12	ca. 40	4	present	750	present study
Tsugaru Strait	13	—	26–28	—	—	4 (rarely 3)	present	700	present study
Mutsu Bay	11–13	ca. 16	24–26	—	—	—	absent	—	present study
Sado	13–14	—	23–29	—	—	—	present	680	Tokioka, 1962a
Anamizu Bay (0 m)	13–15	ca. 15	20–25	ca. 12	—	—	absent	—	present study
Ishikawa Pref. (0 m)	13–15	12–15	ca. 28	up to 20	up to 60	2–4	present	825	present study
Misaki	13	15	30	—	many	—	present	—	Redikorzev, 1927
Sagami Bay	13–14	12–16	25–32	ca. 15	up to 80	2 (rarely 4)**	present	860	Tokioka, 1953c
Osaka Bay	13–14	12–16	ca. 20	ca. 16	—	—	present	—	Tokioka, 1954c
Korea	13–15	12–15	20–30	—	40–65	—	—	770–860	Rho, 1971
Korea	10–14	12–16	19–24	—	—	—	—	800	Rho, 1975
Hawaii (34–65 fms)	13–15	12	18–23	—	50–60	—	present	—	Tokioka, 1967c
Truk (1–3 m)	14	—	24	—	—	—	—	—	Nishikawa, 1984a
W. Australia	11–12	15	25	10	—	4	present	800	Kott, 1963
S. Australia (24 m)	8–10	15	19–25	8	—	3	—	—	Kott, 1972a
S. Australia (7 m)	11–15	ca. 8	18–20	12	—	—	—	—	Kott, 1976
S. Australia	—	—	—	—	—	3	—	900	Millar, 1966

*) For extremely wide range see the text.

**) Given by my reexamination.

This may be consistent with the fact that in many polyclinid ascidians, the stigmal rows of blastozoids increase in number to some extent during successive asexual generations (see Nakauchi, 1982).

Remarks. The present specimens from the Japan Sea conform very well to the original and subsequent descriptions of *A. pliciferum* (except that by Tokioka, 1953c) in colony appearance as well as in many features of zooids and larvae (see Table 3). The only significant difference is the number of larval ampullae. Tokioka states that "three pairs of elongated bulbs (=ampullae in this context)" are recorded "in the anterior portion" (p. 184) of larvae from Sagami Bay colonies. In the present specimens, however, several median unpaired ampullae are known to alternate with 3 attachment processes (see Table 3). To clarify this difference, I examined Tokioka's material deposited at BLIH. The material consists of 5 specimens, only 2 of which (Proto. Nos. 31 and 52, corresponding to Nos. 167 and 180 in Tokioka's description, respectively) contain colonies with fully mature larvae, measuring about 800 μ m in trunk length. Most of them have only 2 median ampullae alternating with 3 attachment processes. Among 16 mature larvae removed from a 73 mm \times 50 mm colony of No. 52, however, twelve have 2 median ampullae, two have 4 median ampullae, and one has a single median ampulla between the dorsal and median processes, in addition to a pair of lateral ampullae along the interval between the median and ventral processes. Another larva has a single median ampulla between only 2 (instead of 3 in all other examined larvae) attachment processes. The last two cases can be considered a kind of malformation. No such larvae having 3 pairs of ampullae as described by Tokioka were found in the present material. Thus, the difference mentioned above does not seem to be real and Tokioka's material from Sagami Bay is undoubtedly *A. pliciferum*.

Distribution in Japan Sea. Rishiri Is., Bikuni and Yobetsu of Hokkaido, Tsugaru Strait, Mutsu Bay, Anamizu Bay and Uchiura-cho on the eastern coast of Noto Pen. and off Echizen-cho, Fukui Pref., 0-5 m (in the present study); Sado Is. (Tokioka, 1962a); the Korean coasts facing the eastern waters of Korea and the Korean Strait (Rho, 1971, 1975).

Distribution outside Japan Sea. See Table 3; and further, Minoshima, Kii Pen., 1-2 m (Nishikawa, 1980b); Ago Bay, down to 3 m (Nishikawa, unpublished); Seto Inland Sea, 0 m (do.); Usa, Kochi Pref. (Nakauchi, 1973).

15. *Aplidium glabrum* (Verrill, 1871)

Amaroucium glabrum Verrill, 1871a, p. 288, figs 20-22.

Aplidium (*Amaroucium*) *glabrum*: Berrill, 1950, p. 109, fig. 32.

For other synonyms and references see Van Name (1945, pp. 31-32).

Material examined: None.

Distribution in Japan Sea. Western coast of South Sakhalin (Skalkin, 1959); around Otaru, Hokkaido, 142 fms deep (Tokioka, 1967c); Tsugaru Strait, 47 fms

(Tokioka, 1967c).

Distribution outside Japan Sea. "Partially circumpolar in the Arctic and northern regions" excepting Alaska, 0–200 fms (Van Name, 1945, p. 33); eastern coast of Sakhalin, 52 fms (Tokioka, 1967c); Akkeshi, Pacific coast of Hokkaido (Tokioka, 1951a); Wakayama, 130 m (Nishikawa, 1980b).

16. *Aplidium translucidum* (Ritter, 1901)

Amaroucium translucidum Ritter, 1901, pp. 249–251, pl. 30, figs 29–30.

For other synonyms and references see Van Name (1945, pp. 54–55).

Material examined: None.

Distribution in Japan Sea. Peter the Great Bay (Beniaminson, 1976).

Distribution outside Japan Sea. Alaska, down to 13 fms (Van Name, 1945); off Alaid Is., Northern Chishima (=Kurile) Isls (Oka, 1933b); Tanjskaja Bay, northern part of Okhotsk Sea, 29–57 m (Redikorzev, 1937).

17. *Aplidium takii* (Tokioka, 1959)

Amaroucium takii Tokioka, 1959b, pp. 237–238, pl. 19, figs 3–4, text-fig. 1.

Material examined: None.

Remarks. Recorded by Tokioka (1959b) from the Tsushima Strait, 10 miles east off Okinoshima Is., situated off Fukuoka Pref., 85 m deep.

18. *Amaroucium ordinatum* (Sluiter, 1906) *sensu* Skalkin, 1959

Amaroucium ordinatum: Skalkin, 1959, p. 245.

Material examined: None.

Remarks. Skalkin (1959) recorded this species from the west coast of South Sakhalin in the Japan Sea, otherwise this species has been known only from antarctic waters (see Monniot & Monniot, 1983a, p. 25), sites too distant from Skalkin's locality. Skalkin did not provide any morphological information of his specimens. Therefore, its exact affiliation cannot be determined here.

19. *Synoiicum clavatum* (Oka, 1927)

(Fig. 3)

Polyclinum clavatum Oka, 1927e, p. 501, fig. 965.

Synoiicum clavatum: Tokioka, 1954b, pp. 69–70, pl. 4, figs E–F; Nishikawa, 1980b, tab. 1.

Synoiicum ?clavatum: Millar, 1975, pp. 255–257, fig. 39.

Material examined: C-8 (Oki): Shirane-zaki, Dogo Is., 3–5 m, 12 colonies.

Description. Colony consists of 1 to 11 cormidia that are hemispherical, cylindrical or thick clavate in appearance (Fig. 3), attached to substratum usually by more or less expanded base. The largest colony is 32 mm \times 20 mm in extent and comprises 11 cormidia, up to 15 mm long and 8 mm in diameter, issuing from a common basal mass of test (Fig. 3, A). Test surface sparsely coated, though never impregnated, with sand grains and other foreign materials such as hydrozoan colonies and algal fragments. Test rather tough, translucent to nearly opaque; colored orange around tip of cormidia, but slightly paler in their proximal part and the basal mat; impregnated densely and evenly with minute white spherules. Systems indistinct. Zooids pale yellow and more or less contracted; thorax up to 2 mm long, usually longer than abdomen; postabdomen up to 15.5 mm. Branchial aperture terminal and 6-lobed, while the atrial is subterminal, smooth-margined and

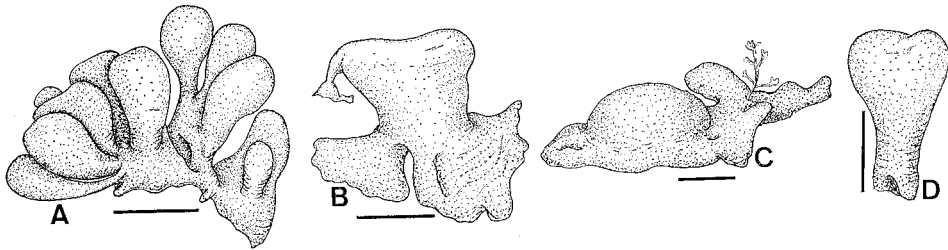


Fig. 3. *Synoicum clavatum* (Oka) from Oki Islands (Collection C-8). A-D, variation in colony form. Scales indicate 10 mm.

provided with a simple or trifold short atrial languet located slightly anterior to the aperture. About 20 to 24 longitudinal muscles on each side of thorax. Tentacles represented by 6(?) conical papillae; ciliated groove a round orifice. Fine transverse muscular filaments discerned only microscopically on the thorax between stigmatal rows. About 10 to 12 stigmata in each half of 15 to 16 (or rarely 18) rows. Dorsal languets displaced to the left of dorsomedian line. Anus bi-lobed, opening nearly at the level of third(?) stigmatal row counted from posterior. Stomach smooth, yellowish orange, roughly a quarter the length of abdomen and the cardiac end slightly lower than middle of abdomen. Very small rectal coeca rarely found. Postabdomen densely packed with numerous small vesicles of unknown nature. Gonad indiscernible. Heart cylindrical and situated at the posterior end of abdomen.

Remarks. These specimens are different from Tokioka's (1954b) redescription of the type material of *S. clavatum* as follows: in the present specimens the colony consists of one to 11 cormidia, hemispherical, cylindrical or thick clavate, issuing from the expanded basal mass, while it is reported by Tokioka to be composed of several cormidia, each of which comprising oval head and elongated stalk, joined to one another by their basal ends; about 20 to 24 thoracic longitudinal muscles are found on each side in the present specimens, while only 12 muscles in Tokioka's; the transverse muscles on the thorax between stigmatal rows are present in the former, while indiscernible in the latter. These differences might be of taxonomic signifi-

cance. The more or less encrusting appearance of some colonies and the existence of transverse muscles on the thorax in the present material may be reminiscent of *S. tsukusii* Tokioka, 1960 so far recorded only once from the Ariake Sea. *S. tsukusii* has 12 longitudinal muscles on each side of thorax and 14 stigmatal rows (Tokioka, 1960b). At present, however, the specimens from the Japan Sea are assigned to *S. clavatum* on the basis of the frequent occurrence of more or less clavate cormidia within the colony; the transverse thoracic muscles are so fine that they may be overlooked easily.

In the specimens collected from Kei Island and referred provisionally to *S. clavatum* by Millar (1975), the colony is "a group of short more or less flat-topped columnar lobes arising from a basal common mass which may be wide or narrow" (p. 255), which resembles some colonies in the present material. Millar's description of the zooids is consistent with Tokioka's mentioned above. Therefore, Millar's specimens are here identified with this species.

The external appearance of *S. clavatum* from the Japan Sea, consisting of several cormidia issuing from a common basal mass, may be shared with *S. solidum* Redikorzev previously recorded from the Okhotsk Sea and having 15 stigmatal rows (Redikorzev, 1937, pp. 125–126). *S. clavatum* from the Japan Sea may be distinguishable, though not so distinctly, from *S. solidum* by much longer thorax and abdomen (6 mm and 4 mm respectively) and by having non-areolated surface on the stomach.

Distribution in Japan Sea. Oki Isls, 3–5 m (in the present study).

Distribution outside Japan Sea. Sagami Bay (Tokioka, 1954b); off Wakayama Pref., 80–100 m (Nishikawa, 1980b); Kei Is., Banda Sea, 20 m (Millar, 1975).

20. *Synoicum pellucens* Redikorzev, 1927

Synoicum pellucens Redikorzev, 1927, pp. 392–394, fig. 13.

Material examined: None.

Remarks. This species has previously been found by Redikorzev (1927) only once from Amur Bay, near Vladivostok, 30 m deep. The species resembles *S. pelucidum* (Ritter et Forsyth) described from the mediolittoral zone of La Jolla, California by Ritter & Forsyth (1917, pp. 482–483) in many significant features of colony and zooids. These two species differ from each other in only one, minor morphological character, i.e., the stomach has many fragmentary longitudinal or oblique ridges in the Russian species and the counterpart in the Californian species is quite smooth. More crucial comparisons between these two species, as well as other related ones, is expected in the future.

21. *Synoicum* sp. *sensu* Skalkin, 1959

Synoicum sp.: Skalkin, 1959, p. 245.

Material examined: None.

Remarks. Skalkin (1959) listed *Synoicum* sp. from the western coast of South Sakhalin without any morphological information.

22. *Placentela crystallina* Redikorzev, 1913

Placentela crystallina Redikorzev, 1913, pp. 212–213, fig. 6.

Sigillinaria clavata: Skalkin, 1959, p. 245.

For other synonyms and references see Nishikawa (1984c).

Material examined: None.

Remarks. *Sigillinaria clavata* Oka was regarded as a junior synonym of *Placentela crystallina* Redikorzev by Nishikawa (1984c).

Distribution in Japan Sea. West coast of South Sakhalin (Oka, 1933a; Nishikawa, 1984c; Skalkin, 1959).

Distribution outside Japan Sea. Various localities in the Okhotsk Sea, down to 65 m; east coast of Kamchatka; Chishima Isls; off Nemuro, Hokkaido, 10–30 m (see Nishikawa, 1984c).

23. *Pseudodistoma antinboja* Tokioka, 1949

Pseudodistoma antinboja Tokioka, 1949b, pp. 39–41, pl. 8, fig. 1, text-fig. 1; Rho, 1971, pp. 108–109, pl. 1, figs 4–6; Nishikawa, 1980b, tab. 1.

Material examined: None.

Remarks. The occurrence of this species in the Japan Sea is recorded only by Rho (1971) from Cheju Is., Korea Strait.

Distribution outside Japan Sea. Tanabe Bay (Tokioka, 1949b) and Hikigawa-cho, 6 m deep (Nishikawa, 1980b), on the west coast of Kii Pen.

24. *Ritterella* sp. aff. *aequalisiphonis* (Ritter et Forsyth, 1917)

Ritterella sp. aff. *aequalisiphonis*: Tokioka, 1967c, pp. 56–58, fig. 17.

Material examined: None.

Remarks. This species was recorded only once by Tokioka (1967c) from Hakodate, Tsugaru Strait; since then, no other specimens have yet been collected from the Japan Sea.

Family Didemnidae

25. *Didemnum* (*Didemnum*) *moseleyi* (Herdman, 1886)

(Fig. 4)

Leptoclinum moseleyi Herdman, 1886, p. 272, pl. 37, figs 9–14.

Didemnum (*Didemnum*) *moseleyi*: Tokioka, 1953c, pp. 185–188, pl. 15, figs 1–8, pl. 16, figs 1–11, pl. 17, figs 1–6; Nishikawa, 1980b, tab. 1 (part; for details see the synonymic list of *D. (D.) granulatum* below).

For other synonyms see Kott (1981, p. 169).

Doubtful record: *Didemnum moseleyi*: Romanov, 1976, pp. 171–172, fig. 4.

Material examined: B (Mutsu Bay): No. 241 (S321), labeled by Oka as *Leptoclinum cribrinum*, collected by Kokubo and Kamada, off Noheji, on Aug. 22, 1926, many small colonies: No. 307 (S312), as *L. sextum*, collected by Hozawa and Takatsuki on the east coast of Yunoshima Is., off Asamushi, on Aug. 5, 1926, a colony, 60 mm × 15 mm in extent and 1 mm thick; No. 337 (S310), as *L. cribrinum*, collected by Hozawa and Kokubo, 1.5 km off Sumichigai, Shimokita Pen., on Aug. 11, 1926, many colonies, 13 mm × 4 mm and 1 mm in the largest. C-1 (Hokkaido): Yobetsu, 1–3 m, a colony covering the whole surface of *Amphiroa* (?) sp., 20 mm × 15 mm and about 2 mm; Kamomejima Is., Esashi, 3–7 m, 4 colonies encrusting algal branches, 55 mm × 30 mm and up to 2 mm thick in the largest. C-6 (Anamizu Bay): A colony, roughly 10 mm × 15 mm and 1 mm, from undersurface of boulder, collected among the colonies found very abundantly. C-8 (Oki): Shirashima, Dogo Is., 3–5 m, several colonies, the largest being 16 mm × 11 mm and 1 mm; Izanaki-ura, Nishinoshima Is., 1–3 m, several colonies from the surface of *Polycarpa cryptocarpa kroboja*, the largest 12 mm × 7 mm and 1 mm; Chinzaki, Nishinoshima Is., 1–6 m, several colonies from the surface of *Halocynthia hispida* and some bivalve shells, 25 mm × 15 mm and 1 mm in the largest; Kuniga, Nishinoshima Is., 1–4 m, 6 colonies, the largest 14.5 mm × 10 mm and up to 1.2 mm. D (Tottori): Several small colonies collected in Apr., 1978. M (Oga): Station A-9, 39°48'N and 139°45'E, 102–104 m, a very small colony; Unosaki, 6 m, 5 colonies found attached to algal branches, the largest being 22 mm × 10 mm and up to 1 mm; already listed by Nishikawa (1984b).

Description. The surface of living colony is beautiful orange in some colonies from Shirashima or snowy white in those from Chinzaki, Kuniga, Esashi and Anamizu, as well as the other colonies from Shirashima. Colony flat and encrusting; surface nearly smooth, though sometimes elevated slightly above the zooids. Superficial spicule-free layer usually indistinct, or very thin if present, except in colonies from Kuniga and Shirashima where the layer is distinct and rather thick. Spicules are found densely and evenly distributed throughout the colony, except in the colonies from Esashi and Anamizu in which spicules are distributed more or less densely in surface layer around the thoracic part of zooids and in the thin layer beneath

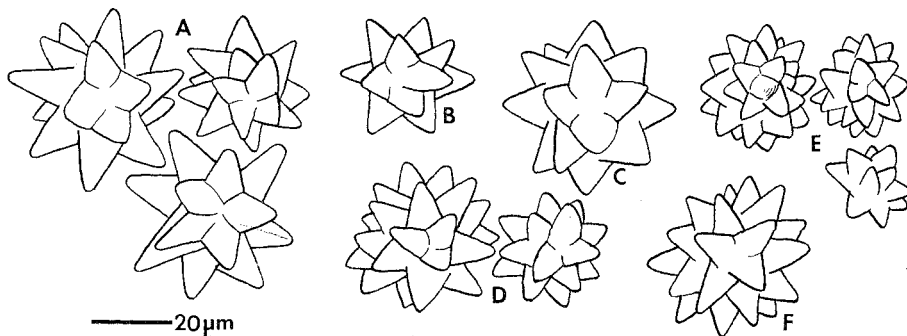


Fig. 4. *Didemnum (D.) moseleyi* (Herdman). Spicules. A. from Yobetsu, Hokkaido (Collection C-1); B. from Mutsu Bay (B, OCUT No. 307 (S312)); C. Mutsu Bay (B, OCUT No. 337 (S310)); D. Esashi, Hokkaido (C-1); E. Anamizu Bay, Noto Pen. (C-6); F. Oki Isls (C-8).

thoracic lacunae, but more sparsely in the remainder of colony. Spicules 10 to 50 μm (20 to 30 μm on an average) in diameter; 7 to 12 (rarely 14) rays rather stout conical, sharply or bluntly pointed at the tip (Fig. 4). Lacunae present on thoracic zone only and very spacious. Zooids more or less contracted; thorax 250 to 500 μm , and nearly as long as abdomen. Atrial aperture wide and without languet; a small thoracic lateral organ situated on the mantle near the posteroventral corner of the aperture on each side. Tentacles about 8 in the zooids examined; 6 to 8 stigmata in each half of 4 rows. Intestinal loop lies nearly horizontally. Ovary, if present, contains a single ovum, about 200 to 250 μm in diameter. Testis always simple; proximal end of vas deferens coiling 6 to 10 (or rarely 11) times. Larvae found only in colonies from Kuniga and Izanaki-ura; 300 to 320 μm in trunk length, with 3 attachment processes and 4 pairs of lateral ampullae.

Remarks. The present specimens fall within the wide range of variation of *D. (D.) moseleyi* (Herdman) shown by Tokioka (1953c, 1967c). Such variation has led to the statement that "more than a single species is included in the records" of this species (Kott & Goodbody, 1980). Indeed, the present species and *D. (D.) pardum* Tokioka, 1962 (see below) may be nearly indistinguishable from each other if the specimens lacked the larvae.

The uneven distribution of spicules and the surface without any projections in some colonies make the present material similar to specimens collected in Hong Kong and identified as *Didemnum aspersum* Tokioka, 1953 by Kott & Goodbody (1980, pp. 515 and 517). They may be distinguishable from Kott & Goodbody's material by the spicules being composed of "numerous" (but apparently only about 10 according to their figure a of plate 2) "short conical rays" (p. 517) in the latter. Romanov (1976) recorded *D. moseleyi* from Vostok Bay in the subarctic waters; colonies were about 30 mm in diameter and 1.5 to 2.5 mm thick, the surface smooth, superficial aspicular layer thick, lacunae in the thoracic zone only, density and distribution of spicules undescribed, spicules 25 μm in diameter on an average and star-shaped, rays short and pointed at the tip, 7 or 8 rays on the equatorial plane only on the basis of his text-fig. 4b, no atrial languet, thoracic lateral organ two-thirds as long as thorax and situated along the (ventral) side of atrial aperture on each side, testis simple, vas deferens coiling 4 or 5 times. Romanov's material appears to be consistent with the description of *D. (D.) moseleyi*, but greatly differs from the latter in the thoracic organ, which is much larger. Thus, Romanov's material is here identified with the present species with doubt.

Distribution in Japan Sea. Yobetsu, 1–3 m (in the present study); off Kamui-misaki, 59 fms (Tokioka, 1967c); Esashi, 3–7 m (in the present study); Tsugaru Strait, 47 fms (Tokioka, 1967c); Mutsu Bay (do.); Oga Pen., down to 104 m (Nishikawa, 1984b; in the present study); Sado (Tokioka, 1967b); Anamizu Bay, 0 m (in the present study); Wakasa Bay (Tokioka, 1959a); Oki Isls, 1–6 m and Tottori, 0 m (in the present study); the eastern waters of Korea and Korean coasts facing Korea Strait (Rho, 1971, 1975); ?Vostok Bay (Romanov, 1976).

Distribution outside Japan Sea. "Common and ubiquitous Indo-West Pacific" (Kott, 1981, p. 169), down to 400 m; Pacific coast of Costa Rica (Tokioka, 1972).

26. *Didemnum (Didemnum) granulatum* Tokioka, 1954

(Fig. 5, A)

Didemnum (Didemnum) moseleyi f. *granulatum* Tokioka, 1954a, pp. 244–245, pl. 21, figs 1–4; Tokioka, 1970, p. 82, fig. 1, 6.

Didemnum granulatum: Kott & Goodbody, 1980, pp. 517–518, fig. 6.

Didemnum (Didemnum) moseleyi: Nishikawa, 1980b, tab. 1 (part).

For other synonyms see Kott (1981, p. 167).

Material examined: C-8 (Oki): Shirashima, Dogo Is., 3–5 m, 2 colonies, 16 mm × 13 mm in extent and 1 mm thick, and 13 mm × 5 mm and 1 mm.

Description. Living colony snowy white. Colony flat, encrusting, the whole surface densely covered with minute protuberances that are composed of spicules; superficial spicule-free layer indiscernible. Spicules distributed very densely and evenly throughout the colony; 10 to 50 μ m in diameter, about 25 μ m on an average; the rays slender conical, pointed at the tip, and 6 to 8 in number on the equatorial plane (Fig. 5, A). Lacunae in the thoracic zone only. Zooids pale orange; thorax up to 500 μ m, nearly as long as abdomen. Six stigmata in each half of 4 rows. Ovarian egg about 250 μ m in diameter. Testis rarely found, undivided; proximal part of vas deferens coiling 2 (?) times.

Remarks. This taxon was originated as a form of *D. (D.) moseleyi*, and was later recognized as a distinct species by Kott & Goodbody (1980). If its granulated surface was not taken into consideration, *D. granulatum* resembles *D. moseleyi* very much. However, the spicules of *D. granulatum* tend to be slenderer and have fewer rays than those of *D. moseleyi*, as noted by Kott & Goodbody.

Distribution in Japan Sea. Oki Isls, 3–5 m (in the present study).

Distribution outside Japan Sea. Sabiura, southern end of Kii Pen., 1–2 m, and Hatakejima Is., Tanabe Bay (Nishikawa, 1980b, then listed as *D. (D.) moseleyi*); Tokara Isls (Tokioka, 1954a); Hong Kong (Kott & Goodbody, 1980); Mindro Is. (Tokioka, 1970); Palau (Tokioka, 1967c); Fiji, Hawaii and Circum-Australian (see Kott, 1981).

27. *Didemnum (Didemnum) pardum* Tokioka, 1962

(Fig. 5, B-D)

Didemnum (Didemnum) pardum Tokioka, 1962b, pp. 266–268, text-fig. 4.

Didemnum (Didemnum) moseleyi: Nishikawa, 1984b, p. 150 (at least in part).

Material examined: B (Mutsu Bay): No. 349 (S307), collected by Hozawa and Takatsuki off Tsubakiyama, northern end of Natsudomari Pen., on Aug. 2, 1926, 5 colonies or fragments covering leaves of *Zostera* sp. or other materials, the largest 60 mm × 50 mm and 1.5 mm thick. C-1

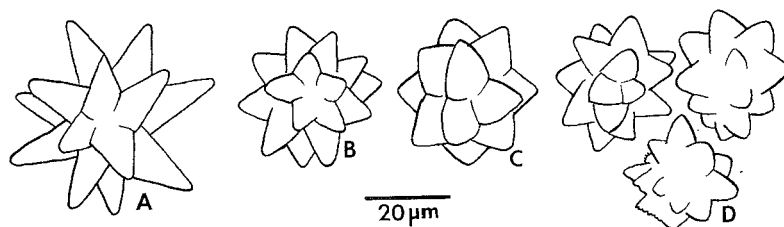


Fig. 5. Spicules. A. *Didemnum* (*D.*) *granulatum* Tokioka; B-D. *Didemnum* (*D.*) *pardum* Tokioka. A. from Oki Isls (Collection C-8); B. from Mutsu Bay (C-2); C. Mutsu Bay (B, OCUT No. 349 (S307)); D. from Esashi, Hokkaido (C-1).

(Hokkaido): Kamome-jima Is., Esashi, 3-7 m, one colony 40 mm × 45 mm and 1 mm or thicker, covering algal stems. C-2 (Mutsu Bay): from buoys of net cages off Moura, 7 colonies, some encrusting *Mytilus galloprovincialis* and *Styela clava*; 80 mm × 55 mm and up to 2 mm in the largest. M (Oga): from buoys off Toga, many colonies investing the surface of *M. galloprovincialis* or *S. clava*, the largest 55 mm × 65 mm and up to 2.5 mm; already listed as *D. (D.) moseleyi* by Nishikawa (1984b).

Description. Living colony is pale orange in the specimens of C-2 and M, but the color of living zooids is unknown. After preservation the colony becomes pale pink with or without a slightly brownish tint, or pale orange. Colony surface quite smooth; superficial aspicular layer very thin or barely discernible. Spicule density is variable from colony to colony, but evenly distributed in each colony, except those of M that have spicules located densely in the surface layer of colony, but rather sparsely in the rest. Branched cloacal canals sometimes seen very obscurely through the surface. Spicules of *moseleyi*-type; 10 to 30 μ m in diameter in the colonies of B, 10 to 35 μ m in those of C-1 and C-2, and 10 to 40 μ m (usually 20 to 30 μ m) in those of M; the rays conical, pointed bluntly at the tip and 8 to 10 in number on equatorial plane (Fig. 5, B-D). Hypozooidal layer of test thin but containing numerous larvae. Lacunae very spacious mainly in the thoracic zone, and sometimes down to abdominal, or rarely further to hypozooidal zone. Zooids more or less contracted; thorax usually shorter than abdomen; thorax 250 to 600 μ m long, abdomen 450 to 700 μ m long. Atrial aperture wide, lacking languet; a small thoracic lateral organ borne on the mantle close to the posteroventral corner of the aperture on each side. Retractor muscle slightly longer than thorax. Intestinal loop lying nearly horizontally; the second loop distinct. About 8 stigmata in each half of 4 rows. Ovary contains a single ovum, up to 300 or 400 μ m in diameter. Testis undivided; the proximal end of vas deferens coiling 8 to 11 times. Some features of larvae are:

Source	Trunk length (μ m)	Number of lateral ampullae
B	500-625	6 pairs; or rarely 16-18 ampullae
C-1	500	6 pairs; or rarely 11
C-2	400-500	6 pairs
M	500-625	6 pairs; or rarely 13-14

No median ampullae. Three attachment processes.

Remarks. These specimens from the Japan Sea closely resemble *D. (D.) moseleyi*, but are clearly distinguishable from the latter in the number of larval ampullae (basically 6 pairs in the present specimens, 4 pairs in *D. moseleyi*). Of the species assigned to the subgenus *Didemnum* of the genus *Didemnum* and recorded from Japan and adjacent waters, the following 4 species are known to have 6 pairs of larval ampullae: *D. areolatum* Tokioka, *D. misakiense* (Oka et Willey), *D. pardum* Tokioka and *D. pacificum* Tokioka. Among these, the present specimens are most similar to *D. pardum* in the flat encrusting colony, the dense and usually even distribution of *moseleyi*-type spicules, the orange color of living colony (but not of zooids) and the thoracic organ situated near the posteroventral corner of atrial aperture. On the other hand, these specimens may be somewhat different from *D. pardum* especially in having the spicules with 8 to 10 rays, while 6 to 8 rays in *D. pardum*. Moreover, the test contains spots composed of black pigments only in *D. pardum*, and the vas deferens coils 8 to 11 times in these specimens, while 7 to 8 times in *D. pardum*. These differences can be regarded to be of little taxonomic significance.

Distribution in Japan Sea. Esashi, Hokkaido, 3–7 m and Mutsu Bay, shallow waters (in the present study); Oga Pen., shallow waters (Nishikawa, 1984b; in the present study).

Distribution outside Japan Sea. Sagami Bay, 10 fms (Tokioka, 1962b).

28. *Didemnum (Didemnum) albidum* (Verrill, 1871)

Leptoclinum albidum Verrill, 1871, p. 446.

Didemnum candidum: Romanov, 1974, p. 241; 1976, pp. 169–170, fig. 2.

For other synonyms see Van Name (1945, pp. 80–81).

Doubtful synonyms:

Didemnum grande: Romanov, 1974, p. 241; 1976, pp. 170–171, fig. 3.

Didemnum studeri: Romanov, 1976, pp. 172–173, fig. 5.

Material examined: None.

Remarks. The occurrence of this species in the Japan Sea is recorded by Skalkin (1959) from the west coast of South Sakhalin. Romanov's (1976) *D. candidum* Savigny, *D. grande* (Herdman) and *D. studeri* Hartmeyer recorded from Vostok Bay, that are all very distant from other known localities of these species, are identified with *D. (D.) albidum* in the present study, as discussed below.

According to Romanov (1976) his specimens of *D. candidum* are characterized as follows: colony orange, about 1 mm thick, the surface smooth; lacunae in the thoracic zone only; spicules 17 to 51 μ m in diameter and the rays with round tip, 6 to 10 in number on equatorial plane only on the basis of his figure 2b; no atrial languet; testis composed of 2 follicles; coiling of vas deferens 5 to 7 times. Romanov's *D. candidum* may fall within the variation range of *D. albidum* as shown by Hartmeyer (1924) and Van Name (1945), who studied specimens from the Arctic Sea and boreal waters of the Atlantic. The differences are seen in spicule size (ranging from 17 to 51 μ m in diameter in Romanov's *D. candidum*, 50 to 80 μ m or larger on an average in *D. albidum*) and the occurrence of atrial languet only in *D. albidum*. In these

characters, on the other hand, Romanov's *D. candidum* resembles the specimens collected from the Chishima Isls and referred to *D. albidum* by Romanov (1974) (the spicules being 15 to 30 μm in diameter), or those from Akkeshi on the Pacific coast of Hokkaido and referred also to *D. albidum* by Tokioka (1951a) (the spicules 25 to 35 μm). Apparently all these specimens from the northern Pacific represent a local form of *D. albidum* inhabiting commonly the Arctic Sea and boreal Atlantic waters; the Pacific form is distinguishable from the Arctic and Atlantic *D. albidum* by the small spicules and the absence of atrial languet. Romanov's *D. candidum* is here regarded as a synonym of *D. albidum*. Tokioka's *D. albidum* mentioned just above was once synonymized with *D. grande* (Hartmeyer) by Kott (1962) and Eldredge (1966); however, this treatment is invalid because the spicule rays in Tokioka's colonies are quite rounded at the tip, while in the type material of *D. grande* from Cebu, the Philippines, the rays are sharply pointed (see Herdman, 1886).

Specimens collected from New Zealand and referred to *D. albidum* by Michaelson (1924) and Brewin (1951) were recently identified as *D. densum* (Nott) by Millar (1982b). Some of the specimens dredged in the Philippines and referred to *D. grande* by Van Name (1918) were identified, though doubtfully, as *D. moseleyi* by Kott (1981). Further taxonomic revision of *D. albidum*, *D. grande* and other related species is expected in the future.

Romanov's *D. grande* is pale orange, 1 to 1.5 mm thick and with smooth surface; lacunae in the thoracic zone only; spicules 25 to 35 μm in diameter and distributed densely and evenly throughout the colony; the rays usually short and of nearly equal width along their whole length, and truncated at the tip (but rounded or bluntly pointed on the basis of his figure 3b); atrial languet nearly or completely absent; testis undivided (?); vas deferens coiled 3 to 5 times. In the size and shape of spicules, Romanov's *D. grande* is similar to some specimens of *D. grande* described by Van Name (1918), but the shape of spicules in the former resembles those of *D. albidum* as shown by Van Name (1945, fig. 33) and Tokioka (1951a, fig. 1, 1). Therefore, in the present study, Romanov's *D. grande* is treated as a synonym of *D. albidum*.

Romanov's *D. studeri* is pale yellow or pale orange, less than 2 mm thick; lacunae rudimentary (?); spicules distributed more or less evenly and rather sparsely, star-shaped and about 20 μm in diameter on an average; the rays long (but short conical according to his figure 5d) and pointed at the tip, 5 to 10 rays on the equatorial plane counted by me on the basis of that figure; thoracic organ large; no atrial languet; retractor muscle as long as thorax; testis composed of 2 follicles; vas deferens coiled 5 or 6 times. Romanov's *D. studeri* may be similar to the previous description of *D. studeri* so far recorded exclusively from antarctic and subantarctic waters by Kott (1969b), especially in the shape and size of spicules, the long retractor muscle and the subdivided testis. However, these similarities, except that seen in the retractor muscle are shared also by *D. albidum*. I believe that the length of retractor muscle is not a stable character. Moreover, the place where Romanov found *D. studeri* is far isolated from all the other localities of *D. studeri*. Thus, Romanov's *D. studeri* is identified here with *D. albidum*.

Distribution outside Japan Sea. Arctic and subarctic waters, down to 410 m deep, including Chishima Isls (Romanov, 1974, 1977) and Akkeshi, Hokkaido (Tokioka, 1951a).

29. *Didemnum* (*Didemnum*) *sp.*

Material examined: C-1 (Hokkaido): Kutsugata-misaki, Rishiri Is., 0 m, a colony from undersurface of stone, 65 mm × up to 18 mm in extent and up to 3 mm thick.

Description. Living colony pale yellowish orange, but changed to pale pink after preservation. Colony encrusting, rather irregular in outline, and tough leathery as in *Leptoclinides* spp. Surface nearly smooth, but elevated slightly in some areas; superficial aspicular layer distinct and seemingly of frothy texture. Colony impregnated densely with spicules in surface layer, while more or less sparsely in the rest. Spicules apparently degraded; mostly 20 to 30 μ m in diameter (ranging from 10 to 50 μ m); usually spherical or somewhat irregular in outline, but sometimes of *moseleyi*-type, consisting of short conical rays with the tip bluntly pointed or rounded, about 10 rays on equatorial plane. Test also contains globular masses of unknown nature especially around abdominal part of zooids; the masses are each enveloped by a transparent and tough capsule, about 50 μ m in diameter. No pigment cells discernible. Hypozooidal layer of colony containing numerous larvae. Thoracic lacunae less extensive, while abdominal ones sometimes present but narrow; hypozooidal lacunae well ramified into many canals not only horizontally but also vertically; the lumen of canals not so spacious. Zooids much deteriorated; thorax about 500 μ m, roughly as long as abdomen. Atrial aperture wide, without any languet. Four stigmatal rows. Testis undivided (?); the proximal part of vas deferens coiling 8(?) times. Larvae also much deteriorated; up to 500 μ m in trunk length, and provided with 3 attachment processes; lateral ampullae present but their exact number unknown.

Remarks. The colony impregnated with spicules and the existence of hypozooidal lacunal system seen in the present specimen is reminiscent of *D. (D.) misakiense* (Oka et Willey, 1892), *D. (D.) spongioides* Sluiter, 1909, *D. (D.) roberti* Michaelsen, 1930, and *D. (D.) lambitum* (Sluiter, 1900). However, further affiliation of the present colony is not possible because detailed features of spicules, zooids or larvae could not be determined due to its poor preservation.

Distribution in Japan Sea. Rishiri Is., Hokkaido, 0 m (in the present study). No other finds are yet known from outside the sea.

30. *Didemnum* (*Didemnum*) *translucidum* Tokioka, 1953

Didemnum (Didemnum) translucidum Tokioka, 1953c, pp. 189–190, pl. 18, figs 5–7; 1962b, pp. 268–270, fig. 5; Nishikawa, 1980b, tab. 1.

Didemnum translucidum: Romanov, 1976, pp. 173–174, fig. 6.

Material examined: None.

Remarks. This species has been reported only once from the Japan Sea by Romanov (1976), who found it in Vostok Bay. Romanov's material agrees with the original and subsequent descriptions or my unpublished material of *D. translucidum* from the Pacific coasts of Japan, except for the number of coils of vas deferens (4 to 6 times in the former, 6 to 10 in the latter). The taxonomic significance of this difference cannot be determined now. Living colonies in Japanese waters generally purplish black, though this coloration soon fades into white after preservation. Romanov's material is described as a "pale milky color," which is probably due to preservation; information about color of living colonies in Vostok Bay is necessary for precise identification.

Distribution outside Japan Sea. Sagami Bay, 150 m (Tokioka, 1953c); west coast of Kii Pen., down to several meters (Tokioka, 1962b; Nishikawa, 1980b); Osaka Bay, 0 m (Nishikawa, unpublished data).

31. *Didemnum (Didemnum) sp. cf. okudai* Tokioka, 1951

Material examined: B (Mutsu Bay): No. 230(S319), referred to *Leptoclinium candidum* by Oka, collected by Hozawa in front of "Enmusubi-jizo", near Asamushi on July 4, 1926, 9 colonies, the largest being 5 mm \times 3 mm in extent and 1 mm thick.

Description. Colony small and flat, encrusting, the surface smooth. Test tough but not hard, nearly transparent and white, frothy or sponge-like texture, impregnated densely with white spherules, about 10 μ m in diameter, but with no spicules or foreign matter. One or two common cloacal apertures in a colony; lacunae in the thoracic zone only. Many epidermal ampullae found issuing from the abdominal (?) part of zooids, and extending into the test throughout the colony including its margin. Zooids contracted; thorax about 250 μ m long, abdomen up to 450 μ m. Atrial aperture wide, without atrial languet or siphon. Six stigmata in each half of 4 rows. Testis undivided; proximal end of vas deferens coiling 8 or 9 times.

Remarks. Oka labeled the present specimens as *Leptoclinium candidum*, although he did not reported them. If this name really represents the taxon now accepted as *D. (D.) candidum* Savigny, the complete lack of spicules in these colonies may be due to ill preservation, for this species is known to be always provided with dense spicules. Contrarily, I think the absence of spicules is an intrinsic feature.

In the frothy texture of test and the complete lack of spicules, the present specimens are similar to *D. pacificum* Tokioka recorded from Sagami Bay (Tokioka, 1953c), but they are distinguishable from the latter by the lack of spacious hypozooidal lacunae and more coils at the proximal end of vas deferens (only 4 times in *D. pacificum*). On the other hand, the present specimens from Mutsu Bay are similar to *D. okudai* Tokioka recorded only once from Akkeshi on the Pacific coast of Hokkaido (Tokioka, 1951a) in the small colony size, complete lack of spicules and presence of epidermal ampullae in the test. However, the presence or absence of epidermal ampullae seems to be of no taxonomic significance, but rather dependent largely on

different physiological or developmental conditions of the colony. The specimens from Mutsu Bay differ from the Akkeshi specimens in the absence of some sand grains included in the test and that of a pair of conspicuous thoracic projections. The original description of *D. okudai* completely lacks details of testis and vas deferens, and, unfortunately, the type material at SMBL seems to have been lost. Consequently, exact affiliation of this species remains unsettled.

Distribution in Japan Sea. Mutsu Bay (in the present study). Distribution outside Japan Sea is unknown.

32. *Didemnum* (*Didemnum*) *risirense* n. sp.

(Fig. 6)

Type series. Holotype colony, 8 mm × 2.5 mm in extent and 1 mm thick in the C-1 material, collected by me at a depth of 1–6 m in front of the Marine Biological Station of Sapporo Medical College, Oshidomari on the northern coast of Rishiri Is., Hokkaido, on Aug. 5, 1983; attached to the holdfast of *Sargassum* (?) sp.; deposited at the Seto Marine Biological Laboratory, Kyoto University (SMBL Type No. 345). About 120 other colonies collected at the same locality are designated as paratypes and deposited at the National Science Museum (Natural History), Tokyo (NSMT-Pc 1097); the largest being about 11 mm × 3 mm in extent, while the smallest 1 mm × 1 mm, and both 1 mm in thickness.

Description. Both living and preserved colonies snowy white. Colony small and flat encrusting; outline elongated oval (Fig. 6, A), rounded, or rarely irregularly undulated along rooty projections of algal holdfast. Colony surface smooth; superficial spicule-free layer present but very thin. Common cloacal apertures indiscernible. No hypozoidal layer of test. Lacunae in thoracic zone only, but very spacious. Many larvae found in the basal part of test. Spicules distributed very densely and evenly throughout the colony, 4 to 36 μ m in diameter, the rays conical and pointed bluntly at the tip, about 10 rays on equatorial plane (Fig. 6, B). Zooids rather ill-preserved; thorax about 300 μ m and abdomen up to 450 μ m long. Branchial aperture terminal and 6-lobed, atrial aperture very wide and lacking atrial languet (Fig. 6, C). Thoracic organ situated on the mantle close to the posteroventral corner of atrial aperture on each side; retractor muscle shorter than thorax. Tentacles and ciliated groove unobservable. About 6 stigmata in each half of 4 rows. Intestinal loop lying nearly horizontally; second loop distinct (Fig. 6, D). A single ovum, up to 250 μ m in diameter, found rarely in the ovary. Testis undivided; the proximal part of vas deferens coiling 8 to 10 times. Larvae oval or round in outline of trunk, up to about 400 μ m in trunk length, provided always with only 2 attachment processes and 3 pairs of lateral ampullae (Fig. 6, E).

Remarks. The distribution and shape of spicules in the present specimens resembles *D. moseleyi*, but the specimens markedly differ from *D. moseleyi* in the number of attachment processes (2 in the former, instead of 3 in the latter). The only other Pacific didemnids in which the larvae have 2 attachment processes are some specimens of *D. candidum* recorded from the Tokara Isls (Tokioka, 1954a), the specimens

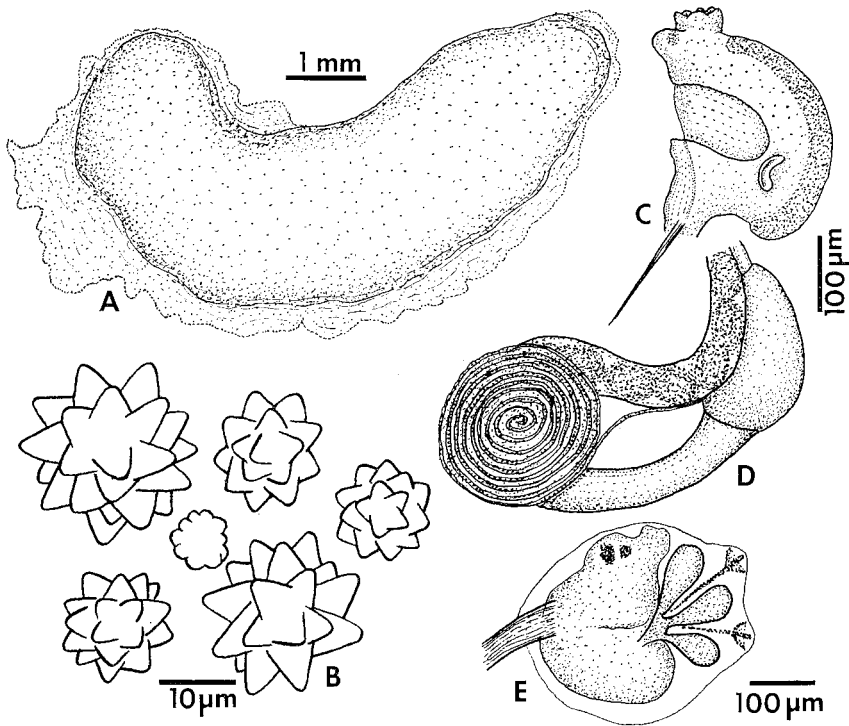


Fig. 6. *Didemnum* (*D.*) *risirens* n. sp. Holotype colony from Rishiri Is., Hokkaido (SMBL Type No. 345). A. top view of colony; B. spicules; C. right side of thorax; D. abdomen; E. larva.

of *Trididemnum aurantiacum* (Herdman, 1886) (as to its affiliation, following Hartmeyer, 1909–1911, p. 1446) from a depth of 38 fms in Bass Strait, Australia (Herdman, 1886), and those of *T. cyclops* Michaelsen, 1921 from Eniwetok Atoll (Eldredge, 1966). Among these, the two species of *Trididemnum* should be left out of consideration here because the present specimens doubtlessly belong to the subgenus *Didemnum*, not to the genus *Trididemnum*. In Tokioka's specimens from Tokara, "among 20 examined larvae from a colony, 15 with three attachment processes, 3 with two processes and 2 with a single process". On the other hand, in the present specimens from the Japan Sea, the larvae are always provided with 2 attachment processes. Further, Tokioka's specimens are different from the specimens from the Japan Sea in the number of rays of spicules on the equatorial plane (about 20 in the former, about 10 in the latter). Thus, the present specimens are regarded as a new species, to which the specific name *risirens* is proposed here after the locality.

Among many species of the subgenus *Didemnum* on the French coasts, according to Lafargue's (1976) revisional work, there are the following 6 species with the larvae having 2 attachment processes: *D. maculosum* (Milne Edwards) (the larvae furnished with 4 to 6 pairs of lateral ampullae), *D. protectum* (Daumezon) (4 to 6 pairs), *D. amourouxii* Lafargue (8 to 9 pairs), *D. coccineum* (Drasche) (8 to 11 pairs), *D. commune* (Della Valle) (5 to 7 pairs) and *D. fulgens* (Milne Edwards) (4 to 8 pairs). All these

French species are distinguishable from *D. risirens* by having more larval ampullae (4 to 11 pairs, instead of only 3 pairs in *D. risirens*).

33. *Didemnum (Polysyncraton) aspiculatum* Tokioka, 1949

Didemnum (Polysyncraton) aspiculatum Tokioka, 1949a, pp. 2-3, pl. 2, figs 1-3; 1953c, pp. 195-196, pl. 20, figs 1-6; Rho, 1975, p. 127, pl. 1, figs 5-7; Nishikawa, 1987, p. 116.

Didemnum (Polysyncraton) simaensis Tokioka, 1949a, pp. 3-4, pl. 2, figs 4-7. (listed as a synonym of *aspiculatum* by Tokioka, 1953c).

Doubtful synonyms and references:

Polysyncraton aspiculatum: Kott, 1962, pp. 301-302, figs 36-38; 1975, pp. 7-8.

Didemnum (Polysyncraton) magnilarvum Millar, 1962a, pp. 165-167, fig. 25.

Polysyncraton magnilarvum: Kott, 1972b, p. 178, fig. 35.

Material examined: B (Mutsu Bay): No. 209(S320), labeled *Didemnoides albidum* by Oka, collected by Hozawa and Ito in front of "Enmushubi-jizo", near Asamushi, on July 14, 1926; a colony, 18 mm × 12 mm in extent and 1.8 mm thick. L-5 (Nanao): 2 colonies, about 40 mm × 40 mm in extent and 4 mm thick, and 40 mm × 25 mm and 3 mm.

Description. Living colonies from Nanao orange, but much paler when kept in alcohol; it turned yellowish orange. Test more or less tough, though not hard, translucent and nearly white; somewhat frothy in appearance only in the colony from Mutsu Bay; densely impregnated with white spherules, up to 10 μ m in diameter, as well as with spindle-shaped cells, about 5 μ m wide. Spicules completely absent in the colony from Mutsu Bay, while found in those from Nanao as distributed exclusively in several small patches over the colony surface, though rather densely therein; the spicules are usually globular, but sometimes slightly deformed, 10 to 60 μ m in diameter, and composed of numerous needles. Hypozooidal layer of test conspicuous only in the colonies from Nanao. Lacunae spacious in thoracic zone only. Many larvae found in the test exclusively in the colony from Mutsu Bay. Zooids pale yellow; thorax up to 1 mm or longer, and abdomen to 1.5 or 2 mm. Atrial aperture wide and provided with a languet expanded distally and sometimes bifurcated at the tip; a small oval thoracic organ often found along nearly the middle of ventral margin of the aperture on each side. About 8 stigmata in each half of 4 rows. Oesophagus elongated and usually furnished with several buds. Intestinal loop nearly vertical; second loop indistinct. Ovarian egg immature, up to 100 μ m in diameter. Testis divided into 8 to 10 follicles in the colonies from Nanao, 4(?) to 6(?) follicles in that from Mutsu Bay; proximal end of vas deferens coiling 2.5 to 3 times. Larvae 900 to 1000 μ m in trunk length and provided with 3 attachment processes and 4 pairs of lateral ampullae; each ampulla usually subdivided into two; organs of oozoid differentiated.

Remarks. The present specimens conform well to the previous descriptions of *Didemnum (Polysyncraton) aspiculatum* Tokioka given by Tokioka (1949a, 1953c) on the basis of the Japanese specimens, only excepting the rare occurrence of spicules in the specimens from Nanao. In the type material of this species, however, "a granulated calcareous concretion" is described to occur within the thoracic organs; according to

the figure 3 of plate 2 in the original description, the concretion may consist of many globular spherules, up to about 20 μm in diameter. Therefore, the type material may be furnished inconspicuously with globular spicules. Thus, the colonies from Nanao, together with that from Mutsu Bay, are assigned to this species. My collection made outside the Japan Sea contains several colonies assigned to this species; they are always furnished sparsely with globular spicules, up to 40 μm in diameter and composed of fine needles.

Kott (1962, 1975) referred some Australian colonies to this species on the basis of similarities in colony structure and zooids. According to Kott (1962), however, in the Australian colonies the spicules are distributed in varying degrees of density and are "stellate with about 12 rays in optical section," while the spicules are globular in the Japanese colonies of the species. The spicules are, if present, also stellate in *D. (P.) magnilarvum* Millar recorded from South Africa and South Australia and regarded by Kott (1975, p. 7) as a junior synonym of *D. (P.) aspiculatum*. Now I cannot evaluate the taxonomic significance of the difference seen in the shape of spicules. Thus, the mentioned Australian and African specimens are here identified somewhat doubtfully with *D. aspiculatum*.

Distribution in Japan Sea. Mutsu Bay, and Nanao Harbor, 0–4 m (in the present study); Korean waters facing the Korea Strait (Rho, 1975).

Distribution outside Japan Sea. Sagami Bay, 16 m–40 fms (Tokioka, 1953c); Mikawa Bay, 0 m (Nishikawa's unpublished data); Matoya Bay, 9–20 m (Tokioka, 1949a); Ago Bay, 3 m, Seto Inland Sea and Kagoshima Bay, 0 m (Nishikawa's unpublished data); Sesoko Is., Okinawa (Nishikawa, 1987); ?West, South and East Australia (Kott, 1962, 1972b, 1975); ?Natal, South Africa (Millar, 1962a).

Didemnum sp. sensu Beniaminsson, 1971

Beniaminsson (1971, p. 319) recorded *Didemnum* sp. in the Japan Sea from Possjet Bay, Peter the Great Bay without any morphological information, and therefore, his record is excluded from the consideration on the ascidian fauna of the sea.

34. *Trididemnum savignii* (Herdman, 1886)

Didemnum savignii Herdman, 1886, p. 261, pl. 34, figs 1–5.

Trididemnum savignii: Van Name, 1921, p. 314, figs 7–9.

For other synonyms and references see Kott (1981).

Material examined: C-5 (Noto): 2 colonies, 10 mm \times 7 mm and 2.5 mm \times 2.5 mm in extent, respectively, and up to 1.5 mm thick, covering the branches of *Sargassum* (?) sp. C-8 (Oki): Chin-zaki, Nishinoshima Is., 1–6 m deep, 5 colonies, the largest being 32 mm \times 10 mm in extent, and up to 2.5 mm thick. D (Tottori): several small colonies collected in Aug. and Dec. 1978.

Description. In living colonies the test and the thorax of zooids dark brown in the specimens of C-8 and D; the preservative alcohol is dyed similarly. Colony flat, encrusting, its surface smooth. Test rather soft, gelatinous, but somewhat frothy in texture, and translucent; impregnated with brownish pigment distributed rather

evenly and very sparsely (in the colonies of C-5) or densely (in those of D), or in those of C-8 with the pigment found very dense in the thoracic zone, while less dense in abdominal and hypoabdominal zones. These zones contain additionally in some places pigment masses, oval or rounded in outline, up to $500\text{ }\mu\text{m}$ in diameter and composed of numerous brownish pigment granules. Lacunae well developed in thoracic zone, and in several places branching into canals in abdominal zone; hypozooidal lacunae absent even in such colonies with thick hypozooidal layer of test as seen in the colonies of C-8. Spicules distributed evenly and very sparsely throughout the colony in those of C-5, while in those of C-8 and D found only in the thin layer between thoracic and abdominal zones and also, though not always, in the bottom floor of lacunal canals. Spicules 10 to $30\text{ }\mu\text{m}$ in diameter (average $20\text{ }\mu\text{m}$) in the colonies of C-5, 10 to $68\text{ }\mu\text{m}$ (average $25\text{ }\mu\text{m}$) in those of C-8 or 15 to $60\text{ }\mu\text{m}$ (average $35\text{ }\mu\text{m}$) in those of D; the rays rather slender, conical and pointed bluntly at the tip, and about 8 to 10 rays on equatorial plane. Zooids more or less contracted; thorax about $400\text{ }\mu\text{m}$ long, and wholly pigmented greenish brown (in the colonies of C-8) or dark brown (in those of D), or sometimes pigmented purplish brown exclusively around the anterior end of endostyle (in those of C-5); abdomen up to $500\text{ }\mu\text{m}$ or longer and colored pale yellow. Atrial siphon distinct. Tentacles about 12 in the zooids examined. Eight to 10 stigmata in each half of 3 rows. Gonad immature.

Remarks. Recently Kott (1981, pp. 184–186) made a taxonomic revision of *Trididemnum savignii* (Herdman) devoted mainly to a distinction of this species from the closely related *T. cerebriforme* Hartmeyer, 1913. However, my unpublished data of Japanese specimens show that Kott's criteria adopted in the revision are not always validated. For instance, the distribution and density of spicules, one of her criteria, are variable among different colonies of a species, when the species is identified on the basis of her other criterion that the hypozooidal lacunae are present in *T. cerebriforme*, and absent in *T. savignii*.

Distribution in Japan Sea. Sado (Tokiooka, 1962a); eastern coast of Noto Pen., 0–2.5 m, Oki Isls, 1–6 m and Tottori, 0 m (in the present study).

Distribution outside Japan Sea. Localities in the Japanese waters are: Sagami Bay (Tokiooka, 1953c), Shimoda (Nishikawa, 1982b), around Kii Pen., 0–40 m (Nishikawa, 1980b), and Kagoshima Bay, 0 m (Nishikawa's unpublished data). According to Kott's list of species records, the localities outside Japan are: Australia; Hawaii; Fiji; Natal, SE Africa; Cape of Good Hope; west coast of Africa; Bermuda; Florida; and Caribbean Sea.

35. *Trididemnum* sp. cf. *cerebriforme* Hartmeyer, 1913

(Fig. 7, A)

Material examined: C-2 (Mutsu Bay): Kaizaki, SE end of Shimokita Pen., 15–20 m deep, from test surface of *Chelyosoma siboga*; a colony, $20\text{ mm} \times 8\text{ mm}$ in extent and 1.5 mm thick.

Description. Colony flat, encrusting; surface quite smooth, with a single common cloacal aperture. Superficial spicule-free layer rather thick. Test rather soft, not fragile, transparent and colorless, containing no pigment at all. Lacunae found in thoracic zone, and in some areas penetrating down to abdominal zone; hypozooidal lacunal canals well developed. Spicules distributed densely and evenly throughout the colony. Spicules 10 to 45 μm in diameter, the rays slender, conical and pointed at the tip, about 9 rays on equatorial plane (Fig. 7, A). Several larvae in the test. Zooids seen obscurely through the surface of the colony. Zooids white; thorax about 500 μm , nearly as long as abdomen. Atrial aperture opening on a very short siphon; thoracic organs indiscernible. About 8 stigmata in each half of 3 rows. Intestinal loop lying nearly horizontally; second loop distinct. Ovary contains a single ovum, about 400 μm in diameter. Testis undivided; proximal part of vas deferens coiling about 10 times. Larvae 500 μm in trunk length, provided with 3 attachment processes and 3 pairs of lateral ampullae.

Remarks. The existence of hypozooidal lacunae in the present specimen is reminiscent of *Trididemnum cerebriforme* Hartmeyer as delimited by Kott (1981). However, the specimen differs from the latter in that the spicules are distributed evenly throughout the colony and the zooids white, while in the latter, the spicules more densely in the upper part and the zooids are furnished with black to brown pigment. It is difficult to evaluate the taxonomic significance of these minor differences when only a single colony is available for this study. Hence, the present specimen is here referred to *T. sp. cf. cerebriforme*.

Distribution in Japan Sea. Mutsu Bay, 15–20 m (in the present study). Distribution outside Japan Sea unknown.

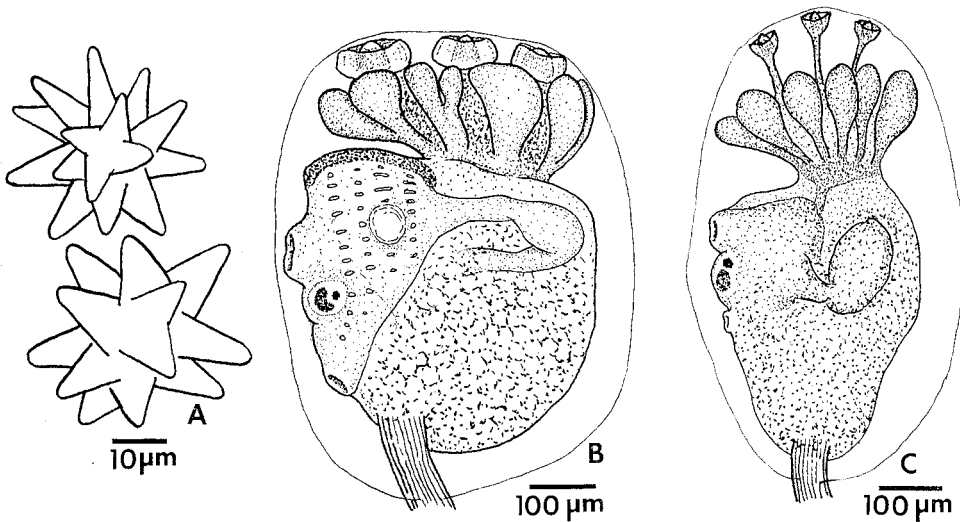


Fig. 7. A. *Trididemnum* sp. cf. *cerebriforme* Hartmeyer from Mutsu Bay (Collection C-2); B. *Leptoclinides komaii* Tokioka from Oki Isls (C-8); C. *Lissoclinum* sp. from Mutsu Bay (Collection B, OCUT No. 344 (S305)). A. spicules; B-C. right side of larva.

36. *Trididemnum alleni* Berrill, 1947 *sensu* Romanov, 1976

Trididemnum alleni: Romanov, 1976, pp. 176–177, fig. 8.

Remarks. The specimens collected in the Japan Sea from Vostok Bay and assigned to *Trididemnum alleni* Berrill by Romanov (1976) are consistent with the original and subsequent descriptions of this species given by Berrill (1947, 1950) mainly in the relatively small thorax (about half as long as abdomen in the former) and the extraordinarily large testis. However, Romanov's specimens are different from these descriptions. In Romanov's specimens, the spicules are distributed so sparsely that thoracic organs of zooids are seen through the colony surface. In contrast, the spicules are distributed very densely and the zooids are not seen externally. This difference may be of certain taxonomic significance. The larvae of *T. alleni* have only 2 attachment processes, but unfortunately Romanov failed to find any larvae in his specimens. Further, *T. alleni* has only been recorded from the Plymouth area, England, 10–30 m deep (see Berrill, 1947, 1950; Carlisle, 1953) and off Morocco, 110–490 m (Pérès, 1959), all quite far apart from Romanov's locality in the Japan Sea. Consequently Romanov's record is questionable.

Although Carlisle (1954a, p. 322) regarded *T. alleni* as a dwarf or young stage of *Didemnum candidum* (= *D. maculosum* defined by Lafargue, 1972), I treat *T. alleni* as a distinct species.

37. *Trididemnum viride* (Herdman, 1906) *sensu* Romanov, 1976

Trididemnum viride: Romanov, 1976, pp. 177–178, fig. 9.

Remarks. According to Kott (1980), the holotype of *Leptoclinum viride* Herdman is not assignable to *Trididemnum* but to the genus *Didemnum*. Further, she reexamined the specimens reported from the Philippines by Tokioka (1967c) as *T. viride* (Herdman) and found that they were identifiable as 3 different species, *T. clinides* Kott, *T. nubilum* Kott and *T. strigosum* Kott. Romanov (1976) recorded *T. viride* from Vostok Bay. As far as judged from the synonym list he gave in his paper, he seems to have identified his specimens based upon the description given by Tokioka (1967c). Romanov's identification should be reconsidered.

Romanov's description shows that his material of *T. viride* had following characteristics: colony less than 1 mm thick; lacunae very spacious, but only in the thoracic zone; spicules distributed more or less evenly throughout the colony (the density was not given), 10 to 25 μ m in diameter, and of two kinds: one stellate and composed of short conical rays (the number unknown), or nearly spherical and of very thin needles; zooids very small, up to 0.8 mm long, thorax as long as abdomen; atrial aperture rather wide, never forming a siphon; thoracic organs conspicuous, about two-thirds as long as thorax; testis undivided (but shown to comprise two follicles by his figure 9b), and the proximal part of vas deferens coiling 7 to 9 times. Symbiotic algal cells, such as described by Tokioka (1967c), were not referred to by

Romanov, and this implies Romanov's material lacked such cells. Thus, Romanov's material is not referable to either of the above-mentioned 3 species, all of which have symbiotic algae.

In the shape and distribution of spicules, Romanov's material from Vostok Bay is similar to *T. tenerum* (Verrill) recorded from northern circumpolar or boreal waters (Van Name, 1945), *T. cereum* (Giard) from European warmer waters (Lafargue, 1974) and *T. delesseriae* Lafargue from the Atlantic coast of France (Lafargue, 1968). The large thoracic organs in Romanov's material is reminiscent of *T. auriculatum* Michaelsen so far known from the Magellanic and Chilean waters (Kott, 1969b). True identity of Romanov's *T. viride* cannot be determined now because its morphological information is insufficient.

38. *Trididemnum microzoa* (Redikorzev, 1913)

Didemnoopsis microzoa Redikorzev, 1913, pp. 208-209, fig. 3.

Material examined: None.

Remarks. Since the original description of this species by Redikorzev (1913) from Mamiya Strait in the Japan Sea, no other record has been published. According to the original description, the present species is characterized as follows: colony massive, up to 65 mm × 40 mm in extent and up to 30 mm thick; test impregnated with roundish bladder cells only, and lacking spicules completely; zooids 2 mm long, thorax as long as abdomen; atrial siphon distinct; 8 stigmata in each half of 3 rows; testis undivided, and the vas deferens coiling 2 to 2.5 times. Hartmeyer (1924, p. 139) regarded this species as a synonym of *T. tenerum* (Verrill), but *T. microzoa* is distinguishable from *T. tenerum* mainly by the number of coilings of vas deferens (2 to 2.5 times in the former, 8 to 10 in the latter, according to Van Name, 1945, p. 99). In the few turns of vas deferens, as well as the absence of spicules, *T. microzoa* may resemble some colonies of *T. strangulatum* (Ritter) so far known from Alaska; in *T. strangulatum* the calcareous spicules are "not found at all in some colonies" and the proximal part of vas deferens coiling 4(?) times (see Ritter, 1901; Van Name, 1945). Further comparison between these two species on the basis of more material is required.

39. *Leptoclinides madara* Tokioka, 1953

Leptoclinides madara Tokioka, 1953c, pp. 200-201, pl. 1, fig. 2, pl. 23, figs 1-6; Rho, 1975, pp. 127-128, pl. 2, figs 1-6; Nishikawa, 1980b, tab. 1; Kott & Goodbody, 1980, p. 522, fig. 10, pl. 3a-b; Kott, 1981, pp. 177-179, fig. 30

Doubtful synonyms:

Didemnoides tigrinum Oka, 1927e, p. 498, fig. 960.

Leptoclinides tigrinum: Tokioka, 1954a, pp. 70-72, fig. 1.

Material examined: C-5 (Noto): 4 colonies, the largest is 60 mm × 10 mm in extent and 2 mm thick. C-8 (Oki): Izanaki-ura, Nishinoshima Is., 1-3 m deep, a single colony, 20 mm × 8 mm and

1.3 mm, investing the test surface of *Polycarpa cryptocarpa kroboja*. G-3 (Noto): A single colony, about 55 mm × 30 mm and up to 1.3 mm, covering a branch of *Cystophyllum sisymbrioides* J. Agardh. G-5 (Tottori): A colony, 17.5 mm × 9 mm and 3.5 mm.

Description. When alive or immediately after fixed with formalin, the colony surface is uniformly orange except thin white areas along the colony margin and around common cloacal apertures in the colonies of C-5, while the surface is pale yellow with dark brownish patches in that of G-3, dull white with orange or dark brown patches in that of G-5, or orange and dark grey in a complex pattern in that of C-8. In the colony of C-8 in preservative alcohol, the surface is pale brown with dark green patches resembling the original description of *L. madara*. Surface quite smooth. Test tough; superficial aspicular layer distinct. Hypozooidal lacunae more or less developed. Spicules distributed densely in the surface layer, while rather sparsely in the rest of the colony; 10 to 40 μ m (about 30 μ m on an average) in diameter, or sometimes up to 60 μ m in the colony of C-8; the rays conical and pointed at tip, 8 to 10 rays (or rarely up to 13) on equatorial plane. Zooids nearly colorless; thorax 300 to 500 μ m and abdomen 300 to 800 μ m long. Atrial siphon distinct and usually directed posteriorly. About 10 longitudinal muscles on each side of thorax; thoracic oragns small and situated on the posterior half of thorax, or even its posterior end. Tentacles about 12. Eight to 10 stigmata in each half of 4 rows. Gonad indiscernible. Only a few larvae found buried in the test of the colony of G-3; about 700 μ m in trunk length and provided with 3 attachment processes surrounded by a low ridge-like prominence, instead of separated ampullae, which may be due to immaturity or some kind of deformation.

Remarks. The present specimens are consistent with the original description of *Leptoclinides madara* Tokioka, although the gonadal structure is unknown in the specimens.

The color of colony surface in living specimens from the Oki Isls (C-8) resembles that of *L. tigrinum* (Oka) recorded from the Japanese waters (exact locality unknown). The holotype of *L. tigrinum* was redescribed by Tokioka (1954a). He suggested that "it is most possible that *Lept. madara* is synonymous with the present species (= *L. tigrinum*) if the difference in the colouration is proved to be of no specific importance" (p. 72). As described above, the coloration in the preservative alcohol of the colony from Oki is almost the same as that in the original description of *L. madara*. Thus, *L. tigrinum* and *L. madara* are probably conspecific. On the other hand, *L. tigrinum* has been regarded as a junior synonym of *L. reticulatus* (Sluiter) by Kott (1962, 1981) and Kott & Goodbody (1980), and Kott (1981) distinguished this species from *L. madara* mainly by the different shape of pigment cells. However, judging from the original description of *L. reticulatus* given by Sluiter (1909), the coloration of colony surface in alcohol seen in some, though not all, of the type specimens is similar to that of some specimens of *L. madara*. Therefore, the conspecificity of these two species may be claimed. In this context, *L. reticulatus* may represent more than a single species, as already pointed out by Hasting (1931, p. 92) and

Kott & Goodbody (loc. cit.) on the basis of the reexamination of the type material.

In *L. madara*, the number of larval ampullae was not given in the original description, but has been reported differently by subsequent authors. Rho (1975) recorded 6 pairs in the specimens from Korea (see her figure 4 of plate 2). On the other hand, 4 pairs are usually discerned in the specimens from Hong Kong by Kott & Goodbody (1980), and in those from Hawaii and referred to *L. rufus* by Eldredge (1966, pp. 220-223) and then transferred to *L. madara* by Kott (1981). And further, only 6 ampullae in all (comprising a single dorsal, a single ventral and 2 lateral pairs) in the specimens from west Pacific and referred to *L. marmoratus* by Millar (1975), but then synonymized partly with *L. madara* by Kott & Goodbody (1980) and Kott (1981). Recently I had a chance to examine the larvae of *L. madara* from Japanese waters. The larvae were embedded in the test of the 4 colonies collected at Daio-zaki, NE coast of Kii Pen., 1-2 m deep on July 25, 1979, and already listed in Table 1 of Nishikawa (1980b); colony surface orange and dark green in a complicated pattern immediately after fixation with formalin, while after preservation in alcohol, only the dark green patches were detected due to dense greyish dark green pigment. These specimens are easily assignable to *L. madara*, based on the general similarities between the specimens and the original description in many important features, such as especially in the coloration of colony surface (see above), the spicules (12 to 55 μm in diameter, about 25 μm on an average, and 8 to 10 conical rays on the equatorial plane in these specimens) and the gonad (usually 4 or sometimes 3 testicular follicles, and the proximal part of vas deferens coiling 5 to 8 times). The larvae in these specimens are 700 μm in trunk length, each provided with 3 attachment processes and only 6 ampullae, comprising a single dorsal, a single ventral and 2 pairs of lateral ones. The larvae are reminiscent of Millar's larvae stated above. The taxonomic significance of the above-mentioned differences in the number of larval ampullae in *L. madara* remains an open question.

Distribution in Japan Sea. Noto Pen., 0-9 m, Oki Isls, 1-3 m and Tottori, 1.5 m (in the present study); Korean shore waters facing Korean Strait (Rho, 1975).

Distribution outside Japan Sea. Sagami Bay (Tokioka, 1953c); around Kii Pen., 0-5 m (Nishikawa, 1980b); Kagoshima Bay, 0 m (Nishikawa, unpublished data); Hong Kong (Kott & Goodbody, 1980); Fiji (Kott, 1981).

40. *Leptoclinides rufus* (Sluiter, 1901) *sensu* Romanov, 1976

Leptoclinides rufus: Romanov, 1976, pp. 174-176, fig. 7.

Remarks. The specimens collected from Vostok Bay in the Japan Sea and assigned to *L. rufus* by Romanov (1976) are characterized on the basis of his own description as follows: colony encrusting, less than 2 mm thick and pale orange; lacunae developed in the posterior half of thoracic zone, or sometimes down to abdominal zone; spicules distributed sparsely only in the upper half of the colony, and of different shapes and sizes; zooids 1.2 to 1.5 mm long, thorax nearly as long as abdomen;

stigmatal rows seen through orangish thoracic wall; atrial aperture usually, though not always just in the same colony, opening on the top of short thin tubular siphon directed posteriad; thoracic organs small and oval, situated on upper half of "neck" region (probably the narrow oesophageal part of abdomen); 2 or 3 pairs of buds on oesophagus in many zooids; testis consisting of 5 or 6 follicles and the proximal part of vas deferens coiling 4 or 5 times.

I think Romanov's *L. rufus* is unique in the position of thoracic organs and thus not assignable to any known species of the present genus or other didemnid genera. Further considerations on the exact classification of the specimens in question cannot be given, because Romanov's description lacks enough information.

41. *Leptoclinides komaii* Tokioka, 1949

(Fig. 7, B)

Leptoclinides komaii Tokioka, 1949a, pp. 4-5, pl. 1, figs 5-8.

Material examined: C-8 (Oki): Jodogaura, Dogo Is., 3-8 m deep, many colonies; the largest being 17 mm \times 14 mm in extent, while the smallest 4 mm \times 4 mm; up to 4 mm thick.

Description. In life the colony surface is dark grey to purplish black, margined with a narrow and nearly white zone; after fixation with formalin, numerous greyish brown pigments, as well as fewer orangish ones, found densely embedded in the surface layer of test. In alcohol, the surface seems slightly greyish dark blue, due to dark green pigment therein, margined with white zones as described above in living colonies; the surface layer of test impregnated densely with elongated pigment cells, up to 20 μ m long, containing numerous dark green granules. The pigment cells very sparse in the rest of colony. In the bottom layer of test are embedded the spherules, up to 100 μ m in diameter and containing such granules as seen in the pigment cells. Colony surface smooth; superficial aspicular layer not apparent. Hypozooidal lacunae well developed, but not extending into thick bottom layer where many larvae are found embedded. Spicules distributed densely and evenly throughout the colony; 10 to 50 μ m in diameter (about 35 μ m on an average) and about 8 conical rays on equatorial plane. Thorax about 300 μ m and abdomen 450 μ m long. About 10 longitudinal muscles on each side of thorax; thoracic organs on the posterior half of thorax. About 10 stigmata in each half of 4 rows. Testis indiscernible; the proximal part of vas deferens coiling only 2 times. Larvae 625 to 700 μ m in trunk length and provided with 4 pairs of lateral ampullae, each sometimes subdivided into 2 or 3 pieces, resulting in 9 to 12 (usually 10 or 11) ampullae around 3 attachment processes (Fig. 7, B).

Remarks. The two turns of the proximal part of vas deferens in the present specimens resembles *L. komaii* Tokioka recorded only once from Matoya Bay, Kii Pen., having the vas deferens as "merely a loop" (though seemingly coiling about 2 times according to Figure 5 of Plate 1 in his original description). The present specimens from the Japan Sea may, however, be different from *L. komaii* from Matoya

Bay in the distribution of spicules (densely and evenly throughout the colony in the specimens, while "sparsely in surface layer only" in *L. komaii*) and the size of spicules (10 to 50 μm in the former, 10 to 20 μm in the latter). These differences might be of taxonomic significance.

As already suggested in the original description, this species resembles *L. dubius* (Sluiter) recorded from the West Pacific, in the small number of coiling of vas deferens, but these two may be distinguishable from each other by the number of testicular follicles (20 to 24 in *L. komaii*, up to 10 in *L. dubius* according to Sluiter, 1909, p. 70; Millar, 1975, p. 238). In the present material of Japan Sea, this important diagnostic character, i.e., the number of testicular follicles, could not be determined. Hence, I admit the identification of the present material is somewhat problematic.

Distribution in Japan Sea. Oki Isls, 3–8 m (in the present study).

Distribution outside Japan Sea. Matoya Bay, 10 m (Tokioka, 1949a).

42. *Leptoclinides* sp. cf. *echinatus* Tokioka, 1954

Material examined: C-8 (Oki): Shirashima coast, Dogo Is., 3–5 m deep, 6 colonies; 17 mm \times 8 mm in extent and 1.5 mm thick in the largest.

Description. In the colonies fixed with formalin, the surface sprinkled with orange and yellowish brown pigment, while in alcohol, slightly brownish white due to the brownish pigment distributed sparsely. Spherical bodies, up to 375 μm in diameter and containing pale brown pigment, included sparsely or sometimes rather rarely in the bottom layer of the colony. Conical or tongue-shaped projections over the colony surface are up to 200 μm long and composed of spicules. Superficial aspicular layer very thin. Spicules distributed evenly and densely throughout the colony; 10 to 50 μm in diameter, about 30 μm on an average and 8 to 10 conical rays on equatorial plane. Hypozooidal lacunae well developed. Thorax about 400 μm and abdomen 500 μm long. About 10 longitudinal muscles on each side of thorax; thoracic organs situated nearly in the middle of thorax. Eight to 10 stigmata in each half of 4 rows. Gonad and larvae indiscernible.

Remarks. In the echinate appearance of colony surface and the shape and size of spicules, the present specimens are similar to *L. echinatus* Tokioka recorded from Osaka Bay (Tokioka, 1954c) and to *L. echinatus* (?) from Shimoda, Sagami Bay (Nishikawa, 1982b, p. 206). Unfortunately, however, the structure of gonad, one of the most significant diagnostic characters in this genus, is unknown in the present specimens.

Distribution in Japan Sea. Oki Isls, 3–5 m (in the present study). Distribution outside Japan Sea is unknown.

43. *Leptoclinides rugosum* Tokioka, 1962

Leptoclinides rugosum Tokioka, 1962a, pp. 5–7, pl. 2, figs 17–18, test-fig. 3.

Material examined: None.

Remarks. This species has been recorded from Sado in the Japan Sea, as well as from Enoshima, Sagami Bay on the Pacific side of Japan by Tokioka (1962a).

44. *Leptoclinides* sp.

Material examined: B (Mutsu Bay): No. 193(S332), labeled *Leptoclinum candidum* by Oka, collected off Hanakuri-zaki, Shirasu, by Hozawa and Takatsuki on Aug. 2, 1926; a single colony, 16 mm \times 4.5 mm in extent, and 8 mm at the thickest.

Description. Colony massive and oval in outline; the surface smooth. Test tough, translucent and colored pinkish, impregnated very densely with spherical bladder cells, up to about 10 μ m in diameter, and rather densely with globular bodies of up to 20 μ m or more in diameter. The globular bodies contain many minute spherules, and are sometimes opaque and white, appearing as if they were calcareous spicules, though true calcareous spicules are absent completely. Lacunae rather narrow, and developed not only in the surface layer (apparently as thoracic or abdominal lacunae), but also in the core part of colony (as hypozooidal ones). Numerous larvae in the test nearly throughout whole colony. Zooids rather deteriorated; thorax about 350 μ m long, abdomens missing. Atrial siphon present. Eight (?) stigmata in each half of 4 rows. Larvae 500 μ m in trunk length, provided with 3 attachment processes and usually with 6 pairs of lateral ampullae, but sometimes 13 or 14 ampullae.

Remarks. The complete lack of spicules in the present specimen, if intrinsic, may be reminiscent of *L. rugosum* Tokioka (see above), some colonies of *L. hawaiiensis* Tokioka recorded from Hawaii (Tokioka, 1967c), and *L. kerguelenensis* Kott from Kerguelen Is. (Kott, 1954, 1969b). As the detailed structure of the gonad is unknown in the present specimen, its exact identification is impossible.

Distribution in Japan Sea. Mutsu Bay (in the present study). Distribution outside Japan Sea unknown.

45. *Lissoclinum* sp. aff. *japonicum* Tokioka, 1958

Material examined: C-2 (Mutsu Bay): Kaizaki, SW end of Shimokita Pen., 15-20 m deep, 11 colonies from the test surface of *Chelyosoma siboga*; the largest being 20 mm \times 15 mm in extent and less than 1 mm thick. C-8 (Oki): Ooku, Saigo-cho, Dogo Is., 3 m, 15 colonies, the largest being 4.5 mm \times 2 mm and 1 mm; Izanaki-ura, Nishinoshima Is., 1-3 m, many colonies attached to unarticulated calcareous algae, the largest 7 mm \times 3 mm and less than 1 mm thick; Kuniga, Nishinoshima Is., 1-4 m, a colony, 10 mm \times 4 mm and 1 mm.

Description. In life the entire colony surface is dark or pale orange. Colony encrusting and very thin; the surface smooth. Superficial aspicular layer indiscernible. Hypozooidal layer of test very thin. Lacunae developed only in thoracic zone. Many larvae embedded in the test in colonies from Mutsu Bay, while a large parasitic

copepod in that from Kuniga. Spicules distributed very densely and evenly throughout the colony; 10 to 30 μm in diameter in the colonies from Mutsu Bay and Izanaki-ura, 15 to 30 μm in those from Ooku, or 6 to 35 μm in that from Kuniga; all about 20 μm on an average. The spicules are composed usually of conical rays pointed bluntly at the tip, and the number of rays on equatorial plane is 9 to 12 in the colonies from Ooku, 10 to 14 in that from Kuniga, about 12 in those from Mutsu Bay, or 15 in those from Izanaki-ura; only in the colonies from Kuniga and Izanaki-ura, the rays are sometimes flat-tipped rarely to the extent that the spicules look globular. Zooids yellowish, more or less contracted; thorax 250 to 500 μm and abdomen 350 to 500 μm long. Atrial aperture wide, without languet. Thoracic organ borne on the mantle slightly apart from the ventral margin of atrial aperture on each side; the anterior margin of the organ situated slightly posterior to the middle of the thorax excluding the branchial siphon; ear-like in appearance and rather conspicuous, about one-third as long as the thorax defined above. About 8 stigmata in each half of 4 rows. Several buds observable on oesophagus in some zooids. Gonad immature except in the colonies from Mutsu Bay, in which the ovarian egg is up to 500 μm in diameter, although the testis is obscure. Vas deferens apparently straight. Larvae 625 μm in trunk length, provided with 3 attachment processes and usually 4 pairs of lateral ampullae, though very rarely 11 ampullae.

Remarks. The present specimens from the Japan Sea are similar to *Lissoclinum japonicum* Tokioka so far collected only once from Shirahama, Tanabe Bay (Tokioka, 1958). However, the specimens are different from the original description of *L. japonicum* in the thickness of the colony (1 mm or less in the former, 2.5 to 3 mm in the latter) and the coloration of living colony and zooids (orangish colony and yellowish zooids in the former, greyish purple colony and dark red zooids in the latter). As these differences may make some taxonomic distinction between these two, and further, the features of testis is unavailable in the present specimens, they are here referred to as *L. sp. aff. japonicum*.

L. japonicum was regarded with some doubt as a junior synonym of *L. fragile* (Van Name) by Kott (1962, 1976). However, *L. japonicum*, as well as *L. sp. aff. japonicum* described just above, are distinguishable from *L. fragile* by two characters; in *L. fragile* coloration of living colonies is pure white and the lacunae developed in both thoracic and abdominal zones (see, for example, Van Name, 1902, 1945; Tokioka, 1967c; Eldredge, 1966). The specimens collected from Australia and referred to *L. fragile* by Kott (1976) are, however, provided with "pinkish brown pigment cells in the surface test" and "the cloacal cavity" which "is mainly thoracic"; these specimens may be related to *L. sp. aff. japonicum* from the Japan Sea. Anyhow, *L. japonicum* may better be retained here as a good species.

Distribution in Japan Sea. Mutsu Bay, 15–20 m, and Oki Isls, 1–4 m (in the present study). No further finds are yet known.

46. *Lissoclinum* sp.

(Fig. 7, C)

Material examined: B (Mutsu Bay): No. 344(S305), labeled *Leptoclinum sextam* by Oka, collected off Myo-mae, Noheji, by Kokubo and Kamada on Aug. 22, 1906, 4 colonies, apparently intact, covering the calcareous tube of a polychaete, and shells of *Megabalanus volcano* (Pilsbry) (?); the largest being about 60 mm × 20–30 mm in extent, while 26.5 mm × 16.5 mm and 1.7–2 mm thick in the smallest. C-1 (Hokkaido): around Neko-iwa rock, Motoji, Rebun Is., 1–7 m deep; a single colony, 38 mm × 18 mm in extent and 1 mm thick.

Description. Colony extensive, flat and encrusting; the surface somewhat elevated only around respective branchial apertures. Superficial aspicular layer indiscernible in the colonies from Mutsu Bay, while discernible as a very thin one in that from Hokkaido. Hypozooidal layer of test usually thin but sometimes rather thickened. Numerous larvae in the bottom layer of colony in the specimens from Mutsu Bay. Lacunae developed in thoracic zone, and often down to abdominal and further rarely to hypoabdominal zones, to represent the cloacal canal system, that is obscurely seen through the test surface in the colony from Hokkaido. Spicules distributed very densely and evenly throughout the colony in the specimens from Mutsu Bay, while rather densely only in the surface layer and more sparsely in the rest of the Hokkaido colony. In the Mutsu Bay colonies, the spicules are more or less deteriorated; about 10 to 30 μ m in diameter, or very rarely up to 40 μ m; the rays of well-preserved spicules stout conical and pointed bluntly or nearly rounded at tip, 6 to 8 on equatorial plane. Spicules in the Hokkaido colony 10 to 36 μ m in diameter (about 30 μ m on an average); the rays conical and pointed at the tip, 8 to 10 (rarely 6) rays on equatorial plane. Zooids more or less contracted and deteriorated; thorax 300 to 500 μ m and abdomen 450 to 500 μ m long. Atrial aperture rather narrow in the specimens from Mutsu Bay, but wide in that from Hokkaido; without languet; thoracic organs, found only in the latter specimen, small and borne on the mantle just close to the posteroventral corner of the aperture. Six to 8 stigmata in each half row. Gonad empty: proximal end of vas deferens straight. Larvae 650 to 750 μ m in trunk length, with 3 attachment processes, and 6 pairs of lateral ampullae, each of which sometimes subdivided into 2 (or rarely 3) pieces, resulting in 12 to 14 ampullae (rarely 11) in all (Fig. 7, C).

Remarks. The present specimens from the Japan Sea are easily distinguished from *L. sp. aff. japonicum* mainly by the existence of abdominal and hypoabdominal lacunae and the fewer spicule rays. In the mentioned feature of lacunae the present specimens resemble some colonies of *L. aureum* Verrill, 1871 recorded mainly from arctic and boreal Atlantic waters. In *L. aureum*, the testis is composed of 5 to 10 follicles, though there is variation in the development of lacunae and the distribution and shape of spicules (Van Name, 1910). As the detailed structure of testis is unfortunately unknown in the present specimens from the Japan Sea, exact specific identification can not be determined.

Distribution in Japan Sea. Rebun Is., 1–7 m, and Mutsu Bay (in the present study).

47. *Diplosoma mitsukurii* Oka, 1892

(Table 4)

Diplosoma mitsukurii Oka, 1892, pp. 265–268, fig. 1; Tokioka & Nishikawa, 1975, p. 326; Nishikawa & Tokioka, 1976b, p. 386; Nishikawa, 1980b, tab. 1; 1982b, p. 204; 1984b, p. 150.

Leptoclinum mitsukurii: Tokioka, 1953c, pp. 201–202, pl. 24, figs 1–5, text-fig. 5; 1954a, p. 249; 1962a, p. 7; 1963, p. 134; 1967b, p. 240; 1967c, p. 100.

Leptoclinum okai Tokioka, 1949a, pp. 5–6, pl. 2, figs 8–9. (listed as a synonym of *D. mitsukurii* by Tokioka, 1953c).

Leptoclinum macrolobium Tokioka, 1949b, pp. 44–46, fig. 4. (listed as a synonym of *D. mitsukurii* by Tokioka, 1963),

Leptoclinum takeharai Tokioka, 1951a, pp. 21–22, fig. 16. New Synonymy.

Doubtful synonym:

Diplosoma listerianum: Romanov, 1976, pp. 168–169, fig. 1.

Material examined: B: No. 184(S349), labeled *Diplosoma mitsukurii* by Oka, collected at Takaisozaki, NW end of Shimokita Pen., facing Tsugaru Strait, by Hozawa, Takatsuki and Sato on Aug. 17, 1927, a colony covering the whole surface of an algal branch, about 40 mm × 20 mm in extent; No. 345(S306), labeled *D. mitsukurii*, collected by Hozawa and Kokubo off Kozawa, Wakinosawa-mura, Mutsu Bay on Aug. 9, '26, a colony, 35 mm × 30 mm in extent and less than 1 mm thick. C-1 (Hokkaido): Chazu, Bikuni, 3–5 m deep, a colony, 35 mm × 40 mm and 1 mm; Kamomejima Is., Esashi, 1 m, 5 colonies from undersurface of stones or algal branches, the largest being 25 mm × 23 mm and 1 mm. C-2 (Mutsu Bay): from buoys of net cages off Moura, many colonies on *Mytilus galloprovincialis*, *Styela clava*, *Pyura sacciformis* and *Molgula* sp., 22 mm × 15 mm and 1 mm in the largest. C-5 (Noto): a colony, 20 mm × 20 mm and 1 mm. C-8 (Oki): Kamio, Dogo Is., 3–4 m, several colonies, the largest being 28 mm × 9 mm and 1 mm; Chinzaki, Nishinoshima Is., 1–6 m, a colony, 30 mm × 20 mm and 1 mm. M (Oga): from buoys of net cages off Toga, a small colony on *Mytilus galloprovincialis*; listed by Nishikawa (1984b).

Description. Test thin but rather tough, semitransparent and white, due to white globular bodies that are 10–20 μ m (or rarely 30 μ m) in diameter and almost always found very densely throughout colony; the globular bodies containing numerous minute spherules, and sometimes appearing as if they were calcareous spicules under low magnification. Lacunae very spacious in both thoracic and abdominal zones, as described by Tokioka (1953c). Zooids rather large; thorax about 750 μ m or longer, abdomen 500 to 600 μ m. Some zooids colored wholly nearly white, while others sprinkled with brown pigments densely or rather sparsely, excepting younger buds and the branchial sac which are nearly colorless. Atrial aperture very wide. Tentacles about a dozen. Six to 8 (or sometimes 10) stigmata in each half row. The ovarian egg 250 to 350 μ m in diameter. Two testicular follicles; vas deferens straight. Larvae with 3 attachment processes and 4 lateral ampullae, as well as an oozoid and a precocious bud (=blastozooid); see Table 4.

Remarks. The present specimens conform very well to descriptions of *D. mitsukurii* so far known mainly from Japanese warmer waters. As has been suggested by many ascidian taxonomists, this species may be indistinguishable from *D. macdonaldi*

Table 4. Some larval features in *Diplosoma mitsukurii* Oka and related species from different localities.

Species	Locality	Length of larval trunk (μm)	Number of		Author
			larval ampullae	precocious buds	
<i>D. mitsukurii</i>	Hokkaido	750	4	1	present study
<i>D. mitsukurii</i>	Tsugaru St.	350	4	1	present study
<i>D. mitsukurii</i>	Mutsu Bay	500	4	1	present study
<i>D. mitsukurii</i>	Sagami Bay	ca. 400	4	1	Tokioka, 1953c
<i>D. mitsukurii</i>	Matoya Bay	ca. 360*	4	1	Tokioka, 1949a
<i>D. mitsukurii</i>	Tanabe Bay	up to 700	4	1	Nishikawa, unpublished
<i>D. listerianum</i>	Vostok Bay	—	4	—	Romanov, 1976
<i>D. macdonaldi</i>	Mindro	480–500	6	1	Tokioka, 1970b
<i>D. macdonaldi</i>	Central Pacific	500	8**	1	Eldredge, 1966
<i>Diplosoma</i> sp.	Puget Bay	350–500	4	1	Nishikawa, unpublished
<i>D. rayneri</i>	Sydney	—	4*	1	Macdonald, 1859
<i>D. rayneri</i>	Australia	700	4(?)*	1	Kott, 1962, 1966
<i>D. listerianum</i>	SE Australia	500*	4*	1	Rowe, 1966a
<i>D. listerianum</i>	Europe	480*	4	1	Berrill, 1950
<i>D. listerianum</i>	Europe	—	4 or less	1	Lafargue, 1968
<i>D. listerianum</i>	Plymouth	450*	4*	1	Rowe, 1966a
<i>D. listerianum</i>	West Indies	440*	4*	1(?)*	F. Monniot, 1983a

*) According to the figures given by respective authors.

**) Described as "4 pairs lateral ampullae", but judging from the figure, ampullae may be only a total of 4.

Herdman, 1886, *D. rayneri* Macdonald, 1859, *D. pizoni* Ritter et Forsyth, 1917, *D. listerianum* (Milne Edwards, 1841) and some other related species. After examining many specimens collected from various localities and deposited at BMNH, Rowe (1966a) concluded that all the above-mentioned species are conspecific, and claimed that *D. listerianum* was valid, though this is not the oldest available name (see Rowe, 1966b, p. 247). Rowe's proposal has been accepted by Millar (1982b, p. 52), Kott (1981, p. 190), F. Monniot (1983a, p. 41) and others, though not by Lafargue (1968, p. 406, foot note) who claimed that *D. listerianum* (not in the sense of Rowe) may not be related to *D. macdonaldi* or *D. pizoni*. As shown in Table 4, there may be differences among the specimens referred to *D. listerianum* (sensu Rowe) in the number of larval ampullae, which might possibly be of taxonomic significance. I will retain the specific name *mitsukurii* here. It has been recently shown in the genera *Botryllus* and *Botrylloides* that the specimens with apparently similar morphology of colony and blastozoid belong to several different species because of their different life histories and larval features (especially the number of larval ampullae) (see Saito, Mukai & Watanabe, 1981a, b; Saito & Watanabe, 1985). Therefore, the subtle difference

mentioned above in number of larval ampullae seen in *Diplosoma* spp. should not be neglected.

My examination of the type material of *L. takeharai* Tokioka collected in Otaru, Japan Sea coast of Hokkaido and deposited at SMBL (Type No. 76) proved that this species is a junior synonym of *D. mitsukurii*, though no larvae could be found in the material. On the other hand, the specimens collected from Vostok Bay and referred to *D. listerianum* (sensu Rowe) by Romanov (1976) are consistent with previous descriptions of *D. mitsukurii* especially in the number of larval ampullae (see Table 4). Therefore, Romanov's *D. listerianum* might be regarded as conspecific with *D. mitsukurii*. However, *D. mitsukurii* has been so far recorded from warm waters (see below), while Vostok Bay, the locality of Romanov's material, belongs biogeographically to the subarctic region, and, further, the larvae of *D. listerianum* from Atlantic waters and those of *Diplosoma* sp. from the American Pacific Northwest are also provided with 4 lateral ampullae (see Table 4). Thus, Romanov's *D. listerianum* is identified tentatively with *D. mitsukurii*.

Distribution in Japan Sea. Bikuni and Esashi, down to 5 m (in the present study), and Otaru (Tokioka, 1951a), Hokkaido; Tsugaru Strait (in the present study); Mutsu Bay (Tsuchiya & Osanai, 1978; in the present study); Oga Pen. (Nishikawa, 1984b; in the present study); Sado (Tokioka, 1962a, 1967b); Noto Pen., 0–2.5 m (in the present study); Oki Isls, 1–6 m (do.); ?Vostok Bay (Romanov, 1976).

Distribution outside Japan Sea. Tokyo Bay, Tateyama, Mikawa Bay, Osaka Bay, Seto Inland Sea and Kagoshima Bay (Nishikawa's unpublished data); Sagami Bay (Tokioka, 1953c); Shimoda (Nishikawa, 1982b); off Omai-zaki, 34–37 fms (Tokioka, 1967c); Kii Pen., 1–10 m (Tokioka, 1949a, b; Nishikawa, 1980b); Usa, Kochi Pref. (Nakauchi, 1973); Tokara Isls (Tokioka, 1954a); Amami Isls (Nishikawa & Tokioka, 1976a); Hong Kong (Tokioka & Nishikawa, 1975); Thailand (Tokioka, 1967c).

Leptoclinum sp. sensu Hartmeyer, 1906

Hartmeyer (1906, p. 27) listed *Leptoclinum* species from Hakodate, Hokkaido without any morphological description. This record is excluded here from this study because the generic or specific affiliation of the record is not possible.

Family Polycitoridae

48. *Clavelina elegans* (Oka, 1927)

Dendroclavella elegans Oka, 1927a, pp. 555–557, figs A–B.

Clavelina elegans: Nishikawa & Tokioka, 1976b, pp. 68–73, figs 3–5; Tokioka & Nishikawa, 1976, pp. 341–345, fig. 2.

Clavelina fasciculata: Rho, 1971, pp. 109–110.

Material examined: None.

Remarks. Specimens collected from Korean shores facing Korea Strait and

referred to *Clavelina fasciculata* Van Name by Rho (1971) resemble *C. elegans* (Oka, 1927) in the fasciate colony and number of stigmatal rows (17 in the former, and 16 to 30 in the latter). The distinction between *C. elegans* from Japan and adjacent waters and *C. fasciculata* inhabiting the Gulf of California was discussed by Nishikawa & Tokioka (1976b).

Distribution in Japan Sea. Korean inshore waters facing Korea Strait (Rho, 1971).

Distribution outside Japan Sea. Tateyama (Oka, 1927a); Sagami Bay, 70–99 m (Oka, 1927a; Tokioka, 1953c; Tokioka & Nishikawa, 1976); off Sakai, western coast of Kii Pen., about 20 m (Nishikawa & Tokioka, 1976b); Amakusa, Kyushu (Tokioka & Nishikawa, 1976).

49. *Eudistoma* sp. cf. *sagamiana* Tokioka, 1953

(Fig. 8)

Material examined: C-1 (Hokkaido): Chazu, Bikuni, 3–5 m deep, a colony, 15 mm × 10 mm in extent and about 2 mm thick. C-8 (Oki): Kuniga, Nishinoshima Is., 1–4 m, a colony, 2 mm × 2 mm and 2 mm.

Description. In a living colony from Hokkaido, pale yellow zooids were seen through white test. Colony flat, encrusting and containing about 10 zooids in the specimen from Hokkaido, while only 2 zooids in the colony from Oki. Colony surface nearly smooth and without any foreign matter. Test rather tough but not hard, semitransparent to translucent and white; not pigmented. Zooids more or less deteriorated; thorax 370 or 400 μ m long and abdomen more than 1 mm (its posterior part missing) in the specimen from Oki, while in that from Hokkaido, thorax up to 1 mm long and abdomen to 2.3 mm. Both apertures 6-lobed; atrial siphon distinct but not elongated. Thoracic musculature consisting approximately of 16 to 20 longitudinal bundles and 30 to 40 transverse fibers on each side. Tentacles about 12; the larger and smaller ones alternating almost regularly. Ciliated groove as an oval opening elongated transversely. Eight to 10 (in the specimen from Oki) stigmata or about 30 (in that from Hokkaido) per half row. In some well-preserved zooids in the Hokkaido colony, the stomach is situated with its cardiac end at the posterior third of the abdomen, the surface quite smooth (Fig. 8, A); with about 24 testicular follicles. A single immature embryo, about 250 μ m in diameter, incubated in the thorax in the specimen from Oki, while 1 or 2 embryos, up to 1 mm long, in that from Hokkaido. Of these, there is only a single, apparently fully grown larva in the present material; 800 μ m in trunk length, and provided with 3 attachment processes, as well as 11 ampullae that comprise a large ampulla on each side of the dorsalmost process, a small one on each side of the middle process, a single conical one ventral to the ventralmost process, 2 dorsoventrally flattened ampullae between the dorsalmost and middle processes, and 4 columnar ones between the middle and ventralmost processes (Fig. 8, D).

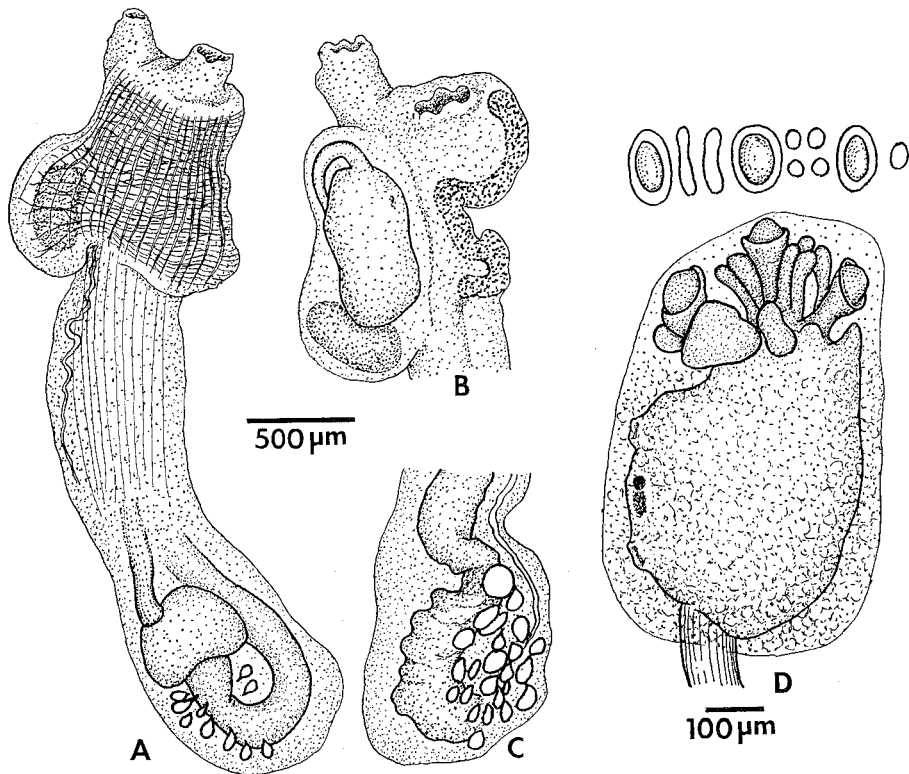


Fig. 8. *Eudistoma* sp. cf. *sagamiana* Tokioka from Bikuni, Hokkaido (Collection C-1). A. right side of whole zooid; B. right side of thorax of a zooid, muscles are omitted to show the incubated embryos clearly; C. abdomen of another zooid; D. right side of larva, the arrangement of median ampullae are shown schematically above.

Remarks. The present two colonies might be assignable to different species, because they are distinct from each other in the size of zooids and the number of stigmata in each row. However, they are here regarded as conspecific, because of the striking similarities between these two colonies in the test and thoracic musculature. The thoracic musculature in the present specimens, consisting of 16 to 20 longitudinal and 30 to 40 transverse muscles, is reminiscent of *E. sagamiana* Tokioka recorded only once from Sagami Bay (Tokioka, 1953c) with about 16 longitudinal and 30 to 40 transverse ones. The present specimens may, however, be distinguishable from *E. sagamiana* mainly by the colony surface (nearly smooth in the specimens, while furnished with many ridge-like swellings in *E. sagamiana*) and the coloration of living colony (nearly white, instead of brownish). These differences may be of certain taxonomic significance. Therefore, the specimens are called as *E. sp. cf. sagamiana*. The specimens also resemble *E. tokarae* Tokioka known from warmer waters around Japan in the thoracic musculature, but are quite different from the latter. In *E. tokarae* the test and the thorax of zooids are sprinkled with dark green pigments.

Distribution in Japan Sea. Bikuni, Hokkaido, 3–5 m, and Oki Isls, 1–4 m (in the present study). Distribution outside Japan Sea unknown.

50. *Eudistoma tokiokai* **nom. nov.**

Eudistoma rubra Tokioka, 1954a, pp. 252–253, pl. 28, figs 2–6, text-fig. 2.

Eudistoma rubrum: Tokioka, 1967c, 117–118, fig. 41b; Nishikawa, 1980b, p. 100; 1984a, p. 119.

Eudistoma sp. aff. *rubrum*: Tokioka, 1962a, pp. 7–8.

Doubtful synonym:

Eudistoma rubra: Kott, 1981, pp. 150–151, figs .5–6.

Distoma rubrum originated by Savigny (1816, pp. 38, 62, 177, pl. 3, fig. 1, pl. 13, figs. 1–9) is excluded as referred to below.

Material examined: None.

Remarks. Tokioka (1962a) referred a small colony collected from Sado in the Japan Sea to *Eudistoma* sp. aff. *rubrum* Tokioka, which is different from the original description of *E. rubrum* in the number of stigmata in each half row (only 6 in the former while 12 to 20 in the latter), even though the colony from Sado has remarkable feature of *E. rubrum*, namely the complete absence of thoracic transverse muscles. I think this difference is of little taxonomic significance.

Eudistoma rubrum Tokioka, 1954, whose specific name was originally spelled erroneously as *rubra* but later corrected by Tokioka (1967c) in concordance in gender (neuter in this case) with the generic name, obviously represents a junior homonym of *Eudistoma rubrum* (Savigny, 1816) (see Hartmeyer, 1919b; Pérès, 1958a). Since *E. rubrum* Tokioka has no available synonyms, *E. rubrum* Tokioka must be replaced by a new name, for which name *tokiokai* is proposed here.

Distribution in Japan Sea. Sado (Tokioka, 1962a).

Distribution outside Japan Sea. Tanabe Bay (Nishikawa, 1980b); Tokara Isls, (Tokioka, 1954a); Gilbert Isls (Tokioka, 1967c); Ponape Is. (Nishikawa, 1984a); ?Fiji (Kott, 1981).

51. *Eudistoma illotum* (Sluiter, 1898)

Distoma illotum Sluiter, 1898, pp. 16–17, pl. 1, fig. 3, pl. 3, fig. 7.

Eudistoma illotum: Millar, 1955, pp. 181–183, fig. 12.

Material examined: None.

Remarks. Except for the records given by Rho (1971, 1975) from the eastern waters of Korea and the Korean inshore waters facing Korea Strait, *E. illotum* has only been recorded from Cape Province, South Africa, down to 70 m deep (Sluiter, 1898; Michaelsen, 1934; Hartmeyer, 1912; Millar, 1955, 1962a, 1964b). Rho's descriptions are too brief to discuss the exact taxonomic position of her specimens.

52. *Distaplia dubia* (Oka, 1927)

(Fig. 9)

Leptobotrylloides dubium Oka, 1927c, pp. 607–608.*Distaplia dubia*: Tokioka, 1953c, pp. 206–207, pl. 1, fig. 4, pl. 11, figs 1–6; 1954c, p. 82; 1963, p. 135; 1967b, p. 240; Rho, 1971, p. 110; 1975, p. 128; Nishikawa, 1980b, tab. 1; 1984b, p. 150. For other synonyms see Tokioka (1963).

Material examined: B (Mutsu Bay): No. 350(S338), labeled *Didemnopsis stellatum* by Oka, collected off Nakago by Takatsuki and Sato on July 24, 1927, a single rather extensive colony covering a branch of *Sargassum* sp.; many larvae and few zooids in the colony. C-2 (Mutsu Bay): from buoys of the net cages off Moura, 21 colonies, some covering *Styela clava*; the largest being 28 mm × 18 mm in extent and 3.5 mm thick. M (Oga): from undersurface of stones in the mediolittoral zone of Daishima, 2 colonies, 4 mm × 3 mm and 2 mm, and 2 mm × 2 mm and 2 mm, respectively; already listed by Nishikawa (1984b).

Description. Colony usually flat, up to 5 mm thick; the surface usually quite smooth, while sometimes depressed markedly between systems in some colonies of C-2 (Fig. 9). Test tough but not hard, translucent to nearly opaque, and colored white (in the colonies of C-2 and M), or greyish green (in that of B); the latter coloration is due to yellow or dark green spherules, about 5 μ m in diameter, distributed densely in the test. Zooids nearly white or pale pink; thorax up to 1 mm long; thorax as long as, or sometimes longer than abdomen. Systems oval or round, each consisting of 10 to 15 zooids; about 20 systems in the 13 mm × 15 mm colony

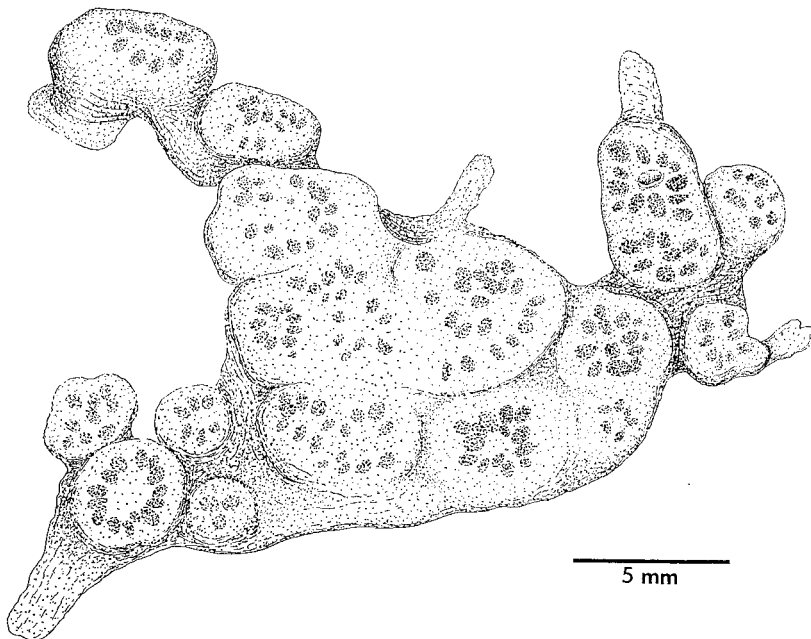


Fig. 9. *Distaplia dubia* (Oka) from Mutsu Bay (Collection C-2). A whole colony, top view.

with smooth surface collected from Mutsu Bay, while only a single system in a 2 mm \times 2 mm colony from Oga. Atrial aperture usually wide except in the specimen from B, in which the aperture opens on the top of a rather elongated siphon directed anteriorly and furnished with a broad languet on its anterior border. Thoracic musculature consists of 15 to 20 fine, longitudinal, or somewhat oblique muscles on each side; several muscle fibers encircling the atrial aperture. About 12 to 15 stigmata in each half of 4 rows; parastigmatic vessels present in the specimens from C-2 and M, but indiscernible in that from B. Gonad mature in the specimens from B and C-2; the ovarian eggs up to 500 μ m in diameter, while the testis comprises 10 to 12 follicles arranged radially. Larvae in the test in the colonies with mature zooids; about 1 mm in trunk length and with 3 attachment processes in a triangle, and sometimes with a well-formed oozoid having 4 stigmatal rows.

Remarks. The present specimens conform very well to the previous descriptions of *Distaplia dubia* (Oka) especially in the zooidal features such as the thoracic musculature consisting of longitudinal muscles. In some colonies from Mutsu Bay, the colony surface appears uneven, depressed markedly between some systems. In this surface structure the colonies from Mutsu Bay resemble *D. systematica* Tokioka described from Tanabe Bay (Tokioka, 1958), but they are clearly distinguishable from the latter by the thoracic musculature. In some colonies of *D. systematica*, the colony surface is smooth (Nishikawa, 1984a). Therefore, the appearance of colony surface seems an unstable character in this genus.

Tokioka (1963) synonymized *D. japonica* Tokioka, 1951, *D. yezoensis* Tokioka, 1951 and *D. imaii* Hirai, 1952 with *D. dubia*, which is followed in the present study, because these four species are indistinguishable. *D. taylori* Brewin from New Zealand (Brewin, 1950a) is similar to *D. dubia* especially in the system (consisting of 6–11 zooids in *D. taylori*) and the thoracic musculature (comprising 15–18 longitudinal muscles in *D. taylori*). But *D. taylori* may be different from *D. dubia* in the number of testicular follicles (4 to 6 in the former, 7 to 14 in the latter) and the size of larvae (up to 2 mm in trunk length, instead of up to 1.2 mm). Specimens collected from Fiji and identified as *D. vallii* Herdman by Kott (1981) resemble *D. dubia* in the zooidal arrangement and the thoracic musculature of zooid, though apparently differ from *D. dubia* in the number of stigmata in each half row (25 in Kott's *D. vallii*, 12 to 20 in *D. dubia*) and the length of larval trunk (1.6 mm, instead of 1.2 mm). In the specimens of *D. vallii* collected from Morocco in the Atlantic and the Celebes Sea (Herdman, 1886) and the Philippines (Van Name, 1918), the thoracic musculature consists of transverse muscles, unlike the musculature of *D. dubia*. However, Kott (1981) doubtfully synonymized *D. dubia* with *D. vallii* on the basis of her own opinion that "variations in the orientation of thoracic musculature (which Tokioka has primarily used to distinguish the species) may only be apparent and result from differences in contraction." The transverse or longitudinal orientation of thoracic muscles seems to me intrinsic features, rather than an artifact. Thus, Kott's synonymy is not adopted here.

Distribution in Japan Sea. Otaru, Hokkaido (Tokioka, 1951a); Mutsu Bay, shallow waters (in the present study); Oga Pen., 0 m (Nishikawa, 1984b; in the present study); Sado (Tokioka, 1967b); the eastern waters of Korea and the Korean inshore waters facing Korea Strait (Rho, 1971, 1975).

Distribution outside Japan Sea. Akkeshi (Tokioka, 1951a); Onagawa Bay, Miyagi Pref. (Hirai, 1952); Sagami Bay (Tokioka 1953c); western coast of Kill Pen. (Nishikawa, 1980b); Osaka Bay (Tokioka, 1951b, 1954c); Seto Inland Sea (Nishikawa's unpublished data).

53. *Distaplia* sp. aff. *dubia* (Oka, 1927)

Distaplia sp. aff. *dubia*: Tokioka, 1967b, pp. 240–243, fig. 1.

Remarks. The specimens collected from Lake Kamo, Sado Is. in the Japan Sea and referred to as *Distaplia* sp. aff. *dubia* by Tokioka (1967b) is unique in the complicated arrangement of zooids and the few longitudinal muscles on the thorax. Therefore, they are distinct from *D. dubia*.

54. *Sycozoa kanzasi* (Oka, 1930)

Colella kanzasi Oka, 1930b, pp. 205–207, figs A–B.

Sycozoa kanzasi: Tokioka, 1953c, pp. 208–209, text-fig. 6, pl. 26, figs 1–7; Rho, 1975, pp. 128–129, pl. 3, figs 4–6; Millar, 1975, pp. 223–224, fig. 16; Nishikawa, 1980b, tab. 1; 1986b, p. 175.

Material examined: N (Oki): a single colony, 20 mm long head with 70 mm long and about 2 mm thick peduncle, already listed by Nishikawa (1986b).

Description. The present specimen agrees with descriptions of *Sycozoa kanzasi*. In life it appeared reddish orange, with branchial apertures yellow; after preservation the colony faded into white. Common cloacal aperture indiscernible; 10 longitudinal rows of zooids on the whole lateral sides of the head, each row comprised of a double series of zooids; numerous thin vessel-like structures embedded longitudinally in the stalk. Thorax about 1.5 mm long, while abdomen 1 mm; atrial languet well expanded; about a dozen stigmata in each half of 4 rows; gonad empty; no embryos.

Remarks. The present species is related to *S. pulchra* (Herdman) recorded from Torres Strait, the Aru Isls, the Java Sea and the Sulu Archipelago, and *S. anomala* Millar from New Zealand and the Scotia Sea (for discussions about their taxonomic relationship see Tokioka, 1953c, p. 209; Millar, 1960, p. 77; 1975, p. 233).

Distribution in Japan Sea. Oki Isls, 35–45 m deep (Nishikawa, 1986b; in the present study); Cheju Is., Korea Strait (Rho, 1975).

Distribution outside Japan Sea. Sagami Bay, about 50 fms–200 m (Oka, 1930b; Tokioka, 1953c; Millar, 1975); Tanabe Bay, 7–40 m (Nishikawa, 1980b).

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(to be continued)